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*Monitoring of salivary and urinary pH
with an external device in order to
improve eating habits: a pilot study*

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I. ABSTRACT (Lingua Italiana)

Secondo la definizione fornita dall'OMS “La prevenzione primaria consiste in azioni volte a rimuovere o ridurre l'esposizione ai fattori di rischio e a promuovere l'adozione di comportamenti e stili di vita sani per prevenire l'insorgenza della malattia”.

I principali vantaggi della prevenzione primaria sono l'impatto a lungo termine sulla salute pubblica e la sostenibilità economica del sistema sanitario.

Le attività di prevenzione primaria non si limitano all'ambito medico stretto, ma includono anche azioni a livello sociale e ambientale, tra cui l'adozione di stili di vita sani e l'eliminazione di abitudini nocive. Cambiamenti nello stile di vita sono notoriamente difficili da implementare su larga scala e richiedono un forte impegno individuale e sociale.

Le nuove tecnologie, in particolare le applicazioni sanitarie (mHealth-mobile Health), hanno un potenziale significativo nel promuovere e implementare la prevenzione primaria nella popolazione. Esse responsabilizzano gli utenti a gestire attivamente la propria salute e a modificare i comportamenti a rischio.

Per poter progettare una app con questo scopo, abbiamo riflettuto su quale parametro oggettivo potesse essere monitorato individualmente dal paziente, in modo economico e semplice.

Abbiamo individuato nel pH questo parametro e nella possibile valutazione quotidiana del pH urinario e salivare.

Questo ci permetteva di fornire ai pazienti un dato oggettivo da controllare per monitorare la sua salute generale e la sua salute orale.

Abbiamo eseguito un'ampia ricerca di letteratura per comprendere l'importanza del pH e l'affidabilità del suo monitoraggio e per sapere quali indicazioni dare ai pazienti sulla base dell'evidence based medicine.

Indagando numerosi articoli, abbiamo individuato 5 grandi temi quali la nutrizione, l'idratazione, la respirazione e la gestione dello stress, il movimento e la cura del cavo orale.

Abbiamo poi valutato lo strumento di misurazione del pH più adeguato e, dopo aver confrontato diversi pHmetri digitali, abbiamo deciso di utilizzare le cartine tornasole in quanto strumento validato, economico, facile da reperire e, sebbene non in grado di fornire misurazioni con grande precisione, sufficientemente affidabile per indicare stati di acidità, neutralità o basicità dei fluidi esaminati.

Abbiamo chiamato l'app HpH Human pH, in quanto non esistono al momento app che permettono il monitoraggio e il controllo nel tempo sia del pH salivare che di quello urinario.

Target dell'app sono individui proprietari di uno smartphone e interessati ad un cambiamento del proprio stile di vita, sia per un miglioramento della qualità della vita, sia per una prevenzione a lungo termine di patologie gravi.

Per progettare al meglio l'app, abbiamo dapprima creato una Survey per Utenti, fornendo prima le informazioni di base a un sample group e poi valutando i risultati del questionario somministrato.

Abbiamo eseguito poi vari tipi di analisi, quali la SWOT (Strengths-Weaknesses-Opportunities-Threats), l'analisi Value Proposition Canvas (Customer Profile e Value Map), l'analisi BMC (Business Model Canvas) e la progettazione di un MVP (Minimum Viable Product).

Sulla base dei risultati dell'analisi, abbiamo progettato l'UX/UI DESIGN Wireframe e inserito i contenuti delle nostre ricerche nell'app.

Gli utenti nell'app possono seguire programmi generali o personalizzati e, in questo caso, essere seguiti da un team multidisciplinare collegato all'app.

Vengono fornite liste di alimenti e acque minerali, video tutorial di ricette o vegetable juices, esercizi di respirazione e meditazione, esercizi fisici, workouts e video online con personal trainers.

Per quanto riguarda il monitoraggio della salute orale, l'app consente di accedere a contenuti per l'apprendimento di una corretta igiene orale, timer per lo spazzolamento, monitoraggio fotografico della placca nel tempo, consigli di alimentazione ed idratazione corretta.

Gli utenti ricevono poi reminders a seconda degli obiettivi da raggiungere e dal livello di pH rilevato.

Abbiamo progettato gli step evolutivi per la creazione dell'app, quali la scelta della tecnologia (native-cross platform- no code/low code), la progettazione del frontend e del backend, la tipologia di testing, le modalità di pubblicazione e manutenzione dell'app stessa.

In seguito alla creazione dei contenuti dell'app, ci siamo resi conto dei possibili sviluppi futuri dell'applicazione quale, ad esempio, l'integrazione con devices quali pHmetri dedicati, spazzolini con pHmetri integrato, borse con sensori, smartwatch per allenamenti personalizzati.

II. ABSTRACT (English Language)

According to the WHO definition, "Primary prevention consists of actions aimed at removing or reducing exposure to risk factors and promoting the adoption of healthy behaviours and lifestyles to prevent the onset of disease."

The main benefits of primary prevention are the long-term impact on public health and the economic sustainability of the healthcare system.

Primary prevention activities are not limited to the medical field, but also include social and environmental actions, including the adoption of healthy lifestyles and the elimination of harmful habits. Lifestyle changes are notoriously difficult to implement on a large scale and require strong individual and social commitment.

New technologies, particularly health applications (mHealth—mobile health), have significant potential to promote and implement primary prevention among the population. They empower users to actively manage their health and modify risky behaviours.

To design an app for this purpose, we considered which objective parameters could be monitored individually by the patient, in a cost-effective and simple way.

We identified pH as this parameter and the potential daily assessment of urinary and salivary pH.

This allowed us to provide patients with an objective measure to monitor their general health and oral health.

We conducted an extensive literature search to understand the importance of pH and the reliability of its monitoring, and to determine what recommendations to give patients based on evidence-based medicine.

By examining numerous articles, we identified five major themes: nutrition, hydration, breathing and stress management, exercise, and oral care.

We then evaluated the most suitable pH measurement tool and, after comparing several digital pH meters, we decided to use litmus paper because it is a validated, inexpensive, easy-to-find tool and, although not capable of providing highly precise measurements, is sufficiently reliable to indicate the acidity, neutrality, or alkalinity of the fluids tested.

We called the app HpH Human pH, as there are currently no apps that allow for monitoring and controlling both salivary and urinary pH over time.

The app's target audience is smartphone owners interested in lifestyle changes, both to improve their quality of life and to prevent serious diseases in the long term.

To best design the app, we first created a User Survey, providing basic information to a sample group and then evaluating the results of the questionnaire.

We then performed various types of analyses, such as SWOT (Strengths-Weaknesses-Opportunities-Threats), Value Proposition Canvas analysis (Customer Profile and Value Map), Business Model Canvas (BMC) analysis, and the design of a Minimum Viable Product (MVP).

Based on the results of the analysis, we developed the UX/UI DESIGN Wireframe and incorporated the findings of our research into the app.

Users can follow general or personalized programs in the app, and in the latter case, be supported by a multidisciplinary team connected to the app.

The app provides lists of foods and mineral waters, video tutorials of recipes or vegetable juices, breathing and meditation exercises, physical exercises, workouts, and online videos with personal trainers.

Regarding oral health monitoring, the app provides access to content for learning proper oral hygiene, a brushing timer, photographic monitoring of plaque over time, and advice on proper nutrition and hydration.

Users then receive reminders based on their goals and the detected pH level.

We have designed the evolutionary steps for the app's creation, such as the choice of technology (native-cross-platform-no-code/low-code), the design of the front-end and back-end, the type of testing, and the methods of publishing and maintaining the app itself.

After creating the app's content, we became aware of the possible future developments of the application such as, for example, integration with devices such as dedicated pH meters, toothbrushes with integrated pH meters, water bottles with sensors, smartwatches for personalized training.

*To Chiara, the love of my life
To my incredible and wonderful children
Linda, Nicolò and Samuel*

III. AIM AND OBJECTIVE OF THE RESEARCH PROJECT

The aim of this thesis is to provide a valid and effective tool to stimulate primary prevention.

Since new technologies enable a personalized and responsible approach to health, a mobile app has been designed that, by measuring objective data such as urinary and salivary pH values, encourages patients to maintain a healthy pH and educates, supports, and monitors them, providing useful information to stimulate lifestyle changes in the areas of nutrition, hydration, breathing, exercise, stress management, and oral hygiene. This highly individualized approach is easier to manage individually than general monitoring by the National Health Service.

Using Behaviour Change Techniques (BCTs), the app allows for personalized interventions, such as prevention plans, based on user data, risk factors, preferences, and progress.

The choice of app design is dictated by the widespread penetration of mobile technology, allowing for reaching segments of the population that are difficult to engage with traditional methods. With the widespread diffusion of smartphones, apps make health information and prevention tools accessible anywhere and anytime, breaking down geographical and logistical barriers.

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VI. LIST OF ABBREVIATIONS

AA: Arachidonic Acid
AAB: Android App Bundle
AGEs: Advanced Glycation End-Products
AI: Artificial Intelligence
ANS: Autonomic Nervous System
APK: Android Package
ASO: App Store Optimization
BCTs: Behaviour Change Techniques
BIA: Bioelectrical Analysis
BMC: Business Model Canvas
BMI: Body Mass Index
BOP: Bleeding On Probing
BV: Bacterial Vaginosis
CAL: Clinical Attachment Loss
CFS: Chronic Fatigue Syndrome
CHT: Circular Hough Transform
CLA: Conjugated Linoleic Acid
CSF: Cerebrospinal Fluid
CKD: Chronic Kidney Disease
CVD: Cardiovascular Disease
DAL: Dietary Acid Load
DHA: Docosahexaenoic Acid
DNA: Deoxyribonucleic Acid
EFAs: Essential Fat Acids
EPA: Eicosapentaenoic Acid
GERD: Gastroesophageal Reflux Disease
GMO: Genetic Modified Organisms
HBS: Household Budget Survey
HCAs: Heterocyclic Amines
HDL: High Density Lipoproteins
HIIT: High-Intensity Interval Training
HPA: Hypothalamic Pituitary Adrenal
HpH: Human pH
HPV: Human Papilloma Virus
HR: Heart Rate
HRV: Heart Rate Variability
ISSN; International Society of Sport Nutrition
KRT: Kidney Replacement Therapy
JF: Junk Food
LA: Linoleic Acid
LCPUFA: Long-Chain Polyunsaturated Fatty Acid
LDL: Low Density Lipoproteins
ME: Myalgic Encephalomyelitis
MMS: MultiMineral Supplements
MVP: Minimum Viable Product
NAE: Net Acid Excretion
NAFLD: non-alcoholic fatty liver disease
NC: Neck Circumference
NEAP: Net Endogenous Acid Production
NHS: National Health System

NK: Natural Killer
OEA: Oleoyl ethanolamide
OVJ: Organic Vegetable Juice
PAHs: Polycyclic Aromatic Hydrocarbons
POC: Point Of Care
PUFAs: Polyunsaturated Fatty Acids
PRAL: Potential Renal Acid Load
RNA: Ribonucleic Acid
RR: Relative Risk
RSA: Respiratory Sinus Arrhythmia
SCFAs: Short-Chain Fatty Acid
sIgA: Secretory Immunoglobulin A
SOD: SuperOxide Dismutase
SQL: Structured Query Language
SSBs: Sugar-sweetened beverages
SWOT: Strengths-Weaknesses-Opportunities-Threats
T2D: Type 2 Diabetes
TDS: Total Dissolved Solids
TWI: Total Water Intake
UGC: User Generated Content
UI: User Interface
UX: User Experience
UPF: ultra-processed food
VLDL: Very-Low-Density Lipoproteins
VPC: Value Proposition Canvas
WHO: World Health Organisation

1. INTRODUCTION

Of all the balances that the human body strives to maintain, one of the most important is the acid-alkaline balance: the pH balance in human bloodstream is one of the most important biochemical balances in the entire chemistry of the human body.

According to “Acid-Base Homeostasis” (Hamm LL et al, 2015), the body maintains blood pH within a narrow range (~7.35-7.45) thanks to the combined action of the buffer, respiratory, and renal systems.

The human body is designed to be alkaline and does everything it can to remain slightly alkaline, in accordance with the characteristics of blood and tissues.

However, all bodily functions produce acidic effects: it is all too easy, and also very common, for the blood and tissues of the body to become acidic.

The fact is that the human body is alkaline in structure but acidic in function. Vital body fluids (arterial blood, extracellular fluid) maintain a slightly alkaline pH (around 7.35-7.45) to enable structural, enzymatic, and chemical functions. The study “Acid-base physiology” emphasizes that “the physiological pH of the human body is essential for many processes ... including oxygen delivery to tissues, correct protein structure, and innumerable biochemical reactions.” (Hopkins et al., 2025). Furthermore, the physiology of acid-base balance shows that the body implements buffer, respiratory, and renal systems to maintain this pH (Mc Namara et al., 2001).

Acids (such as CO₂ from respiration, lactic acids from muscle activity, fixed acids from proteins and phosphates) are generated in daily metabolism and require neutralization/excretion.

The study “Importance of pH Homeostasis in Metabolic Health and Diseases: Crucial Role of Membrane Proton Transport” states that “a typical example is elevation of lactic acid production in skeletal muscle ... which leads to body fluid acidosis ...” (Aoi W, Marunaka Y., 2014). Metabolic functions therefore produce H⁺/acids that need to be managed, so the body must continuously “clean up” this acid load to maintain an alkaline internal environment.

So, the idea is that the body's structure (blood, tissues, enzymes) requires a stable alkaline environment, while metabolic function continuously generates acidity that must be neutralized or eliminated.

In practice, this means that the body needs alkaline fuel, while acids are the by-product of all metabolic activity. If an unbalanced diet is added to this activity, the result is massive hyperacidification of cells, tissues, and organs. This imbalance opens the door to increased susceptibility to disease and illness.

First, when the body is acidic, it is more vulnerable to infection: in a healthy environment, germs cannot gain a foothold.

One article shows that extracellular acidity (lower external pH, e.g., pH 6.0-7.0) activates the NLRP3 inflammasome complex in human macrophages, with the release of IL-1 β . (Rajamäki K et al., 2013). An acidic environment is therefore perceived by immune cells as a “danger signal” that can increase or alter the immune response.

According to the study by Torres et al., an acidic environment can reduce the effectiveness of endogenous antimicrobial peptides, promoting infection. This study conducted on respiratory epithelium shows that in conditions of acidosis (e.g., pH ~6.7 compared to ~7.3), cells exhibit greater cytotoxicity and antimicrobial defences are compromised against *Pseudomonas aeruginosa* (Torres et al., 2017).

The study “pH sensing at the intersection of tissue homeostasis and inflammation” emphasizes that pH alterations (particularly towards acidity) are associated with infections, tissue damage, and chronic inflammation (Hajjar S, Zhou X., 2017).

Finally, in patients hospitalized with COVID-19, an acid-base imbalance (particularly metabolic or mixed acidosis) was found to be a predictor of mortality (Al-Azzam N et al., 2023). This suggests that a systemic state of acidosis (not just local) is a sign of impairment or contributes to the severity of the disease.

In short, good health requires the body to be in an appropriate acid-alkaline balance. A good acid-base balance is a component of health, but it is not the only one, nor is it sufficient on its own to guarantee immunity or disease prevention. Choosing an appropriate diet and lifestyle is the only way to ensure this.

The relationship between acid and alkali is scientifically quantified on a scale from 0 to 14 and is known as pH, which stands for potential hydrogen. On this scale, 7 is neutral. Values below 7 are acidic, those above are basic or alkaline.

Technically, pH reflects the concentration of hydrogen ions (positively charged molecules) in any substance or solution. It is measured on a logarithmic scale in which each unit up (or down) reflects a difference equal to ten times the value. For example, a substance with a pH of 5 is 10 times more acidic than one with a pH of 6; one with a pH of 8 is 10 times more alkaline than one with a pH of 7. Higher values, i.e., more alkaline, mean greater potential for absorption of hydrogen ions or acids; lower values, on the other hand, indicate lower potential.

There are numerous clinical benefits associated with good acid-base balance. First, improved oxygenation and tissue function: the correct pH promotes the proper binding and release of oxygen by haemoglobin (Shaw & Gregory, 2023), while a pH outside the normal range can alter the oxygen dissociation curve, decreasing oxygenation efficiency.

Enzymatic activity and cellular metabolism are more regular: biochemical reactions occur under specific pH conditions; an imbalance can alter protein charge, enzyme conformation, and reduce metabolic efficiency. For example, in conditions of muscle acidosis (during intense exercise), H^+ production can reduce intracellular pH and interfere with muscle contraction.

A good acid-base balance prevents chronic disorders/diseases: chronic acid-base disorders (prolonged acidosis or alkalosis) are associated with renal, metabolic, and respiratory dysfunction. (Kellum, "Clinical review: Reunification of acid-base physiology," 2005). A proper balance limits stress on buffer systems and the kidneys, keeping compensatory mechanisms freer to respond to other challenges.

Finally, it allows for better recovery and greater metabolic resilience: good buffering capacity and a stable acid-base system allow the body to recover more quickly from metabolic exertion, maintaining performance and limiting fatigue due to acid accumulation (Kellum, 2005).

2. PH AND ITS IMPORTANCE

pH is a logarithmic scale used to specify the acidity or alkalinity of aqueous solutions. Solutions (basicity of solutions with higher concentrations of hydrogen cations (H^+)) have lower pH values than basic or alkaline solutions. While the origin of the symbol “pH” can be traced back to its original inventor and the ‘H’ clearly refers to hydrogen, the exact original meaning of the letter “p” in pH is still controversial; since then, it has acquired a more general technical meaning that is used in numerous other contexts (William BJ, 2004).

The pH scale is logarithmic and inversely indicates the activity of hydrogen cations in the solution where $[H^+]$ is the equilibrium molar concentration of H^+ (in $M = \text{mol/L}$) in the solution. At 25°C (77°F), solutions with a pH below 7 are acidic and solutions with a pH above 7 are basic. Solutions with a pH of 7 at 25°C are neutral (i.e., they have the same concentration of H^+ ions as OH^- ions, i.e., the same as pure water). The neutral pH value depends on temperature and is less than 7 if the temperature rises above 25°C . The pH range is commonly given as 0 to 14, but a pH value can be less than 0 for very concentrated strong acids or greater than 14 for very concentrated strong bases (Lim KF, 2006).

The pH scale is based on a set of standard solutions whose pH is established by international agreement. Primary standard pH values are determined using a concentration cell with transfer, measuring the potential difference between a hydrogen electrode and a standard electrode such as a silver chloride electrode. The pH of aqueous solutions can be measured with a glass electrode and a pH meter or a color-changing indicator.

In 1909, Danish chemist Søren Peter Lauritz Sørensen introduced the concept of pH at the Carlsberg Laboratory (Sørensen SPL, 1909), originally using the notation “pH,” with H as a subscript of the lowercase p. The concept was later revised in 1924 to the modern pH to accommodate definitions and measurements in terms of electrochemical cells.

For the number p, he proposed the name ‘hydrogen ion exponent’ and the symbol pH. Thus, the hydrogen ion exponent (pH) of a solution is understood to be the negative value of the Briggsian logarithm of the normality factor of the related hydrogen ion (Sørensen SPL, 1909).

Sørensen did not explain why he used the letter p, and the exact meaning of the letter is still controversial. Sørensen describes a way to measure pH using potential differences, and represents the negative power of 10 in the concentration of hydrogen ions. The letter p could stand for the French *puissance*, the German *Potenz*, or the Danish *potens*, all meaning “power,” or it could mean “potential.” All of these words begin with the letter p in French, German, and Danish, which were the languages in which Sørensen published: Carlsberg Laboratory was French-speaking; German was the dominant language of scientific publications; Sørensen was Danish. Some literary sources suggest that “pH” stands for the Latin term *pondus hydrogen* (amount of hydrogen) or *potent hydrogen* (power of hydrogen), although this is not supported by Sørensen's writings. (Lian Y et al, 2019).

In modern chemistry, p stands for “negative decimal logarithm of,” and is used in the term pK_a for acid dissociation constants, so pH is “the negative decimal logarithm of the concentration of H^+ ions,” while pOH is “the negative decimal logarithm of the concentration of OH^- ions.”

2.1 Blood pH

Blood pH is one of the most tightly regulated parameters in the body. It reflects a slightly alkaline state that is stable enough to support bodily structure and function, while metabolism continuously produces acids that must be neutralized or eliminated. The major regulatory mechanisms—chemical buffers, respiration, and kidney function—work synergistically to maintain balance. When these systems are compromised, pH alterations have significant clinical consequences.

Arterial blood pH is normally maintained within a very narrow range: approximately 7.35–7.45

(ideally 7.40) according to medical resources. (Kellum JA, 1998)

Slightly alkaline blood provides a favourable environment for enzymatic functions, tissue oxygenation, and protein and cell membrane stability (Jabor A, Kazda A, 1995).

Three fundamental independent variables regulate blood pH: partial pressure of CO₂, concentration of related electrolytes, and total concentration of weak acids in plasma (Bourke and Haussinger D, 1992).

The body has several built-in mechanisms to maintain acid-base balance: buffer systems, respiratory regulation, renal regulation, and combined compensations.

The bicarbonate/carbonic acid system (HCO₃⁻ / H₂CO₃) acts mainly in plasma, neutralizing the H⁺ ions produced by metabolism; other buffer systems include phosphates, plasma proteins, and haemoglobin (Kellum JA, 1998).

An increase in CO₂ in the blood (e.g., due to hypoventilation) leads to the production of H₂CO₃ and therefore to an increase in H⁺, causing the pH to drop (acidosis). The body responds by increasing ventilation to “blow out” CO₂ (Bourke and Haussinger D, 1992). Conversely, hyperventilation reduces CO₂ and leads to respiratory alkalosis.

The kidneys regulate acid-base balance in the long term by reabsorbing almost all filtered bicarbonate and producing new HCO₃⁻ to replace that which has been consumed. In metabolic acidosis, the kidneys increase the excretion of ammonium (NH₄⁺) and titratable acids to reduce the acid load (Hamm LL et al., 2015).

In combined compensations, when a primary disorder occurs (e.g., metabolic or respiratory acidosis), the body triggers compensations (respiratory, renal) to bring the pH back to normal. However, compensation does not always completely restore normal pH (Kellum JA, 2000).

Changes in blood pH (acidosis or alkalosis) have significant clinical impacts:

a) Acidosis (pH < 7.35)

Reduces the ability of haemoglobin to release oxygen to tissues (Bohr effect). It can compromise cardiac function, cause arrhythmias, respiratory depression, and cognitive impairment. In metabolic acidosis, there may be an increased risk of multi-organ dysfunction.

b) Alkalosis (pH > 7.45)

Increases neuromuscular excitability (tetany), may reduce cerebral perfusion, and may cause cerebral vasoconstriction (Hamm LL et al., 2015). It can also compromise oxygen release (due to the aforementioned reverse Bohr effect) and compromise electrolyte homeostasis.

c) Cerebrovascular effects

Acid-base imbalances affect cerebral blood flow: for example, acidosis/alkalosis can alter cerebral blood flow (CBF) regulation (Caldwell HG et al., 2021).

Maintaining a stable blood pH is crucial: small changes (even 0.1-0.2 units) can alter enzyme functions, O₂ transport, and cellular functions (Kellum JA, 2000).

In critical conditions (ICU, serious illnesses), the presence of pH alterations is associated with a worse prognosis.

Just as our body temperature must be maintained at 37°C, our blood must also be maintained at the ideal, slightly alkaline pH of 7.365-7.4.

Different areas of the body require different and specific pH conditions, but the blood needs to remain within much narrower limits.

Blood pH is therefore a reliable indicator of overall internal health. Maintaining the alkaline pH of body fluids, including blood, urine, and saliva (and even tears and sweat, although these are not

normally measured), is crucial for good health.

Of these fluids, blood is the most important.

Physiological changes and discomfort are almost always the result of excess acid, which forces changes and therefore stresses the physiological pH balance to the point that the body manifests symptoms. These symptoms may be the expression of this forced change, but they may also be a sign of the effort the body is making to restore balance.

All of the body's regulatory mechanisms (including respiration, circulation, digestion, and glandular functions) work to restore the delicate internal acid-alkaline balance. Our bodies cannot tolerate prolonged acid imbalances.

Although many changes are subclinical and difficult to attribute solely to acidosis, some reported symptoms include:

- Reduction in muscle mass and strength (muscles that 'give way').
- Reduction in bone mineral density, increased risk of osteopenia/osteoporosis.
- Greater predisposition to kidney stone formation.
- Increased blood pressure.
- Reduced insulin sensitivity, possible predisposition to type 2 diabetes.
- General fatigue, feeling of weakness, potentially worsening physical function.

These symptoms are generally associated with high dietary acid load (Carnauba RA et al., 2017).

Some conditions that have been linked (not necessarily caused exclusively) to chronic acidosis include:

- Chronic kidney disease (CKD) and worsening kidney function (Tangri N et al., 2017)
- Osteopenia/osteoporosis and increased risk of bone fractures (Carnauba RA et al., 2017).
- Type 2 diabetes and metabolic syndrome (through alterations in insulin metabolism) (Carnauba RA et al., 2017).
- Hypertension in some studies linked to high acid load (Carnauba RA et al., 2017).
- Reduction in muscle mass (sarcopenia), especially in the elderly or in conditions with high acid load (Naude MTech Hom DF, 2022)

A 2017 review on "Diet-Induced Low-Grade Metabolic Acidosis and Clinical Outcomes: A Review" highlighted that a diet with a high acid load (often due to animal protein/high phosphorus + few alkalizing foods) is associated with several metabolic changes: loss of muscle mass, reduced bone mineral density, kidney stones, increased blood pressure, increased risk of type 2 diabetes (Carnauba RA et al., 2017).

A 2024 study, "Chronic Sub-Clinical Systemic Metabolic Acidosis – A Review with Implications for Clinical Practice," defined the concept of "sub-clinical" acidosis (blood pH at the lower limits of normal) and linked it to an increased risk of chronic diseases and metabolic imbalances (Naude MTech Hom DF, 2022).

In patients with chronic kidney disease (CKD), metabolic acidosis has been associated with faster disease progression, worsening kidney function, and increased mortality (Tangri N et al., 2017).

A downward trend in the body's pH cannot be allowed; to prevent this, when the blood is faced with an excess of acid, it begins to extract alkaline minerals from our tissues to counterbalance it. There is a group of basic minerals that are particularly suitable for neutralizing or eliminating strong acids, including sodium, potassium, calcium, and magnesium. When these minerals react with acids, they create much less harmful substances that are then eliminated from the body.

A healthy body contains extra reserves of these alkaline minerals to respond to emergency demands. But if there are insufficient amounts in the diet or reserves, they are recovered elsewhere and may be taken from the blood (such as sodium or potassium), bones or cartilage (such as calcium), or muscles (such as magnesium), where they are naturally needed. This can easily lead to deficiency states and the many and varied symptoms that follow.

If the acid overload exceeds the blood's ability to balance it, the excess acid is discharged into the tissues as a deposit. Then the lymphatic (immune) system must neutralize what it can and try to get rid of the rest. Unfortunately, ridding the tissues of acid means, in practice, reloading it into the blood. This triggers a vicious cycle of even greater removal of alkaline minerals, taking them away from their normal functions, which, moreover, stresses the liver and kidneys (Tangri N et al., 2017). Furthermore, if the lymphatic system is overloaded or its vessels do not drain properly (a condition often caused by lack of exercise), acid accumulates in the connective tissues (Naude MTech Hom DF, 2022).

This imbalance in the pH of blood and tissues leads to irritation and inflammation and paves the way for disease and illness. Acute or recurring illnesses arise from the mobilization of alkaline mineral reserves in an attempt to prevent cell destruction or from urgent attempts at detoxification by the body. For example, the body may dispose of acids through the skin, causing symptoms such as eczema, acne, boils, headaches, muscle cramps, soreness, swelling, irritation, inflammation, general discomfort, and pain. Chronic symptoms occur when all possibilities for neutralizing or eliminating acids have been exhausted.

When acid residues accumulate in the body and enter the bloodstream, the circulatory system will try to get rid of them in gaseous or liquid form, respectively through the lungs or kidneys (Hamm LL et al., 2015). If there is too much acid waste to handle, it is deposited in various organ systems (including the heart, pancreas, liver, and colon) or in adipose tissue.

This process of demolition and disposal of acidic residues could also be called the aging process; taken to the extreme, it leads to degenerative diseases, facilitating the onset of cancer. All this is caused by dietary, metabolic, and environmental acids.

Food acids come from what we eat and drink. Metabolic acids are created by our bodies as a result of the transformation of what we eat and drink into energy. Environmental acids come from our surroundings, such as air pollution, petroleum products, etc.

2.2 Urinary pH

Urine is a biological fluid produced by the kidneys as a result of plasma filtration, reabsorption, and secretion in the renal tubules.

The main components are:

- Water: constitutes approximately 91-96% of urine in healthy individuals.
- Inorganic solutes and ions: sodium (Na^+), potassium (K^+), chloride (Cl^-), calcium (Ca^{2+}), magnesium (Mg^{2+}), phosphates (PO_4^{3-}), sulfates (SO_4^{2-}) are present in varying concentrations depending on diet, fluid intake, and kidney function.
- Organic solutes: such as urea (derived from protein metabolism), creatinine (muscle metabolite), uric acid, amines, ammonium (NH_4^+), and organic acids.
- Proteins and peptides: in normal urine, proteins are present in very low quantities (< 150 mg/24h in healthy adults) and there is a complex urinary proteome that also reflects health or disease conditions.
- Other components: hormones, metabolites, pigments (e.g., urobilin, which gives urine its color), blood breakdown products, excreted toxins (Ferrão, A.R et al., 2024).

Urinary pH is influenced by various factors, such as diet, hydration status, metabolism, and kidney health, and can reflect the acidity or alkalinity of the body.

Normal urine pH can vary between approximately 4.5 and 8.0 in healthy individuals, with an average value often around 6.0. Variations depend on the time of day, meals, physical activity, diet, and health status.

Urinary pH is the result of renal regulation of acid-base balance and depends on various factors:

1. Renal acid management function

Kidneys manage H^+ secretion, HCO_3^- reabsorption, and the production of new bicarbonates, contributing to the regulation of urinary and systemic pH (Halperin ML et al., 2006).

For example, the study on the physiology of acid-base balance explains that one of the main roles of the kidney is to maintain the ideal urinary pH (approximately pH 6.0) to minimize the formation of stones.

2. Diet and metabolic acid load

Diet is a key factor: high intake of animal protein and phosphates is associated with lower (more acidic) urinary pH; conversely, diets rich in fruit and vegetables tend to produce a more alkaline urinary pH. For example, the study on uric acid excretion shows that an “alkalizing” diet facilitates the excretion of uric acid thanks to a higher urinary pH (Kanbara, A et al., 2010).

3. Buffer balance and ammoniogenesis

The ability to produce ammonium (NH_4^+) in the renal tubules is crucial for acid excretion; a defect in this pathway can lead to persistently low urinary pH (Sakhaee K et al., 2004).

4. Other factors: age, gender, diet, clinical conditions

For example, one study showed that urinary pH tends to decrease with age in patients with kidney stones, even when diet is considered (Menezes CJ et al., 2019).

Another study showed that women have a higher average urinary pH than men when fed identically, suggesting the role of sexual/dietary factors (Worcester EM et al., 2017).

5. Hydration status, urinary volume, and concentration

The amount of water consumed, urinary volume, and solute concentration affect urinary composition and pH.

Monitoring urinary pH is a simple and non-invasive method that can provide useful information about the body's overall health: it offers a range of useful information about the body's health, particularly regarding kidney health, acid-base metabolism, diet, and kidney stone prevention. However, it should be emphasized that, although urinary pH can be a useful indicator, it is not a definitive diagnostic test and must be interpreted in the context of other clinical parameters. Numerous scientific studies have explored the usefulness of urinary pH monitoring in various fields of medicine.

Urinary pH can be an important indicator of acid-base disorders in the body. Changes in urinary pH may be related to conditions such as metabolic acidosis or alkalosis. In particular, monitoring urinary pH has been used to diagnose acid-base disorders in patients with kidney or respiratory diseases (Di Somma et al., 2019). For example, a consistently low (acidic) urinary pH could indicate a condition of acidosis, while a high (alkaline) pH could be associated with alkalosis, both of which require medical attention.

Urinary pH analysis is closely linked to kidney health. The kidneys regulate blood pH through the excretion of hydrogen ions (H^+) and the reabsorption of bicarbonate. Kidney dysfunction, such as nephrotic syndrome or renal failure, can alter urinary pH (Korgaonkar et al., 2017). Furthermore, in

patients with kidney stones, urinary pH is an important parameter: too low or too high a urinary pH can promote the formation of acidic or alkaline kidney stones (Pak et al., 2003).

Another area of interest concerns the relationship between diet and urinary pH. A diet rich in animal proteins, for example, tends to reduce the pH of urine, making it more acidic, while a plant-based diet rich in fruits and vegetables tends to alkalize urine. A diet rich in acidic foods (such as red meat, refined sugars, and grains) tends to acidify urine, creating an environment that could promote inflammatory processes in the body. Diet affects acid-base balance and may play an important role in the prevention of metabolic diseases such as osteoporosis and gout (Frassetto et al., 2001). Several studies have suggested that a lower (acidic) urinary pH may be related to a chronic low-intensity inflammatory state, which has been identified as a risk factor for numerous degenerative diseases (Frassetto et al., 2001; Riley et al., 2012). In particular, low-grade chronic inflammation has been associated with conditions such as atherosclerosis, type 2 diabetes, and neurodegenerative diseases (Calder, 2013). A consistently acidic urinary pH may suggest that the body is struggling to maintain optimal acid-base balance, which can lead to increased levels of oxidative stress and inflammation. Chronic inflammation, in turn, is a key mechanism in the development of degenerative diseases.

Monitoring urinary pH is also particularly useful for preventing the formation of kidney stones. The composition of stones depends largely on the pH of the urine. For example, calcium oxalate stones form more easily in an acidic urinary environment, while calcium phosphate stones tend to develop in an alkaline environment. Studies have shown that a urinary pH between 5.5 and 6.5 is ideal for preventing the formation of kidney stones (Gould et al., 2016).

Urinary pH can also be an indicator of urinary tract infections. Typically, an alkaline urine pH is often associated with urinary tract infections caused by bacteria that produce urease, an enzyme that alkalizes urine. Some studies have found that monitoring urinary pH can be useful in tracking recurrent urinary tract infections (Hooton et al., 2013). In these cases, a high pH could be a sign of infection, suggesting the need for antibiotic treatment.

Some studies suggest that monitoring urinary pH may also be used to improve overall metabolic health and facilitate detoxification processes. An optimal urinary pH (slightly alkaline) could support the body's natural detoxification and improve energy metabolism. However, scientific evidence in this area is still limited, and further research is needed to confirm these effects (Gannon et al., 2014).

Urinary pH monitoring has been associated with several aspects of metabolic and inflammatory health, with potentially relevant implications for susceptibility to degenerative diseases, including cardiovascular disease, osteoporosis, and neurodegenerative diseases. Persistently acidic urinary pH has been suggested as an indicator of chronic inflammation, which may contribute to the onset and progression of these diseases. In this context, urinary pH analysis may prove to be a useful diagnostic tool, although research is still evolving and many of the proposed hypotheses require further experimental confirmation.

Regarding osteoporosis, when the body is in an acidic state, it can draw calcium from the bones to buffer the acidity, resulting in loss of bone density. Studies have shown that an acidic environment can accelerate bone demineralization, increasing the risk of fractures and osteoporosis (Frassetto et al., 2001; Teucher et al., 2009). An alkaline urinary pH, on the other hand, appears to promote better bone health and a lower risk of fractures (Barzel et al., 1998).

Looking at the onset of cardiovascular disease, we see that metabolic acidosis has been associated with increased production of inflammatory cytokines, which play a key role in atherosclerosis and cardiovascular disease. Research has shown that chronic inflammation is an important risk factor for the progression of cardiovascular disease and that an acidic urinary pH could be a sign of such systemic inflammation (Boehm et al., 2010).

Furthermore, acidic urinary pH can promote insulin resistance, another factor contributing to cardiovascular risk (Gannon et al., 2014). Insulin resistance is a condition that frequently develops in

an acidic environment, as chronic inflammation interferes with insulin action, promoting type 2 diabetes and other metabolic disorders.

Some studies have suggested that monitoring urinary pH could be useful as a risk indicator for chronic and degenerative inflammatory diseases, and that correcting an acidic state could have a protective effect. Dietary interventions aimed at alkalizing urine, such as increasing the consumption of fruits, vegetables, and alkalizing minerals (such as potassium and magnesium), could reduce inflammation levels and improve overall health (Frassetto et al., 2001; Riley et al., 2012).

Monitoring urinary pH provides an indirect measure of the body's acid-base status, which may be associated with chronic inflammation and an increased risk of degenerative diseases such as osteoporosis, cardiovascular disease, and neurodegenerative diseases. Although scientific evidence is growing, further research is needed to fully understand the mechanisms by which acidic urinary pH may contribute to the development of these diseases and to determine how pH monitoring and correction can be used in clinical practice.

Measuring urinary pH is most useful when done at specific times of the day, as the value can vary physiologically based on food, stress, physical activity, and circadian rhythms.

The best times to measure it are:

1. In the morning (first urine after waking up) because it represents the most acidic state of urine in 24 hours, useful for assessing the effect of nighttime metabolism and the previous day's diet.
2. In the evening (last urination before bedtime), as it indicates the cumulative effect of diet and lifestyle during the day. It may show a more alkaline tendency, especially after meals rich in vegetables.

It is important to remember that it should not be measured immediately after a meal, as digestion can temporarily alter the pH. Measurement should be avoided during/within 2 hours of intense physical exercise and, if regular monitoring is being carried out, it is recommended to always measure at the same times (e.g., 7:00 a.m. and 9:00 p.m.).

The recommended frequency for clinical or personal use is twice a day (morning and evening), which is the most common and informative approach. In the case of specific monitoring (e.g., alkalizing diet), even 3 measurements may be useful.

2.2.1 Limitations of Urinary pH as a General Health Indicator

1) Individual urine pH is highly variable

A single spot urine pH measurement does not reliably reflect a person's overall 24-hour acid–base balance.

Studies comparing spot urine pH (from a single sample) with 24-hour urine collections (the clinical reference) show poor agreement — mean differences of ~0.5 pH units and decreased accuracy especially for alkaline values (>6.5), meaning spot tests can misclassify pH status (Mohamed et al, 2016).

This variation limits how accurately one single test can represent systemic physiology.

2) Common home testing methods lack precision

Dipstick pH testing — widely used in consumer settings — has insufficient reliability for clinical decision-making. In a clinical comparison, dipstick results often overestimated or underestimated true pH, potentially leading to inappropriate treatment decisions (Kwong et al, 2013).

Another study found that routine test strips have limited comparability with laboratory-measured pH values, meaning results can be imprecise (Abbott JE et al, 2013).

This lack of precision restricts the usefulness of urinary pH measurements outside controlled lab settings.

3) Urine pH is influenced by many non-health factors

A wide range of external and lifestyle factors can alter urine pH independently of systemic health:

- a. Diet: Foods high in fruits/vegetables can increase urine pH; high protein diets lower it.
- b. Hydration state: Drinking habits influence concentration and pH independently of disease (Yıldırım İ, Koçan H, 2023)
- c. Medications and supplements: Bicarbonate, citrate, acetazolamide and others can alter urine pH without pathology.
- d. Infections and urease-producing bacteria: UTI pathogens (e.g., *Proteus*) can raise urine pH, without reflecting systemic metabolic status. [6]

Because diet, drugs, hydration, and bacteria change pH so readily, a urinary pH value may not reflect true metabolic health.

4) Urinary pH is not specific for systemic disease

While urine pH can help detect acid–base disorders (e.g., renal tubular acidosis) and guide management of kidney stones, it is not a sole indicator of general health:

Normal urine pH ranges widely (≈ 4.6 to 8.0). Values within this range may be normal even in the absence of serious disease.

A high pH might simply reflect an infection, certain diets, or renal handling of acids/bases — not necessarily a systemic issue (Hitzeman N et al, 2022).

Thus, urine pH often needs additional clinical context and tests to interpret meaningfully.

5) Interpretation depends on clinical context

Urinary pH can be clinically useful for specific conditions (e.g., stone risk, tubular dysfunction), but its interpretation requires integration with other labs and clinical findings. For example:

Low urine pH may be seen in metabolic acidosis or obesity-related metabolic disturbances, but the direct causal relevance to overall health remains uncertain in many populations (Díaz-Anadón L et al 2022).

This reinforces that UpH should be viewed as one piece of information, not a comprehensive health marker.

2.3 Salivary pH

Saliva is a complex secretion produced mainly by the salivary glands (parotid, submandibular, sublingual) and numerous minor glands. It contains water, ions, proteins, enzymes, cells, and microorganisms. A systematic review describes its composition, salivary flow, and buffering capacity in children and adolescents (Moradi S et al., 2025).

Some key elements of saliva composition are:

- *Water*: this is the predominant component ($>99\%$) of saliva (Baliga S et al., 2013).
- *Inorganic ions*: bicarbonate (HCO_3^-), phosphate (H_2PO_4^- , HPO_4^{2-} , PO_4^{3-}), calcium (Ca^{2+}), sodium (Na^+), potassium (K^+), chloride (Cl^-), etc. For example, the study by Tatevossian & Gould (cited in a study on salivary species) shows that the proportion of phosphate species depends on the pH of saliva (Rovera A et al., 2025).
- *Proteins and enzymes*: mucins, salivary amylase, lingual lipase, lysozyme, lactoferrin, peroxidase, secretory immunoglobulin A (sIgA), and other antimicrobial peptides. A review highlights the role of protein composition in oral health and homeostasis maintenance (Lyngø Pedersen AM, Belstrøm D., 2019).
- *Cells, microbes, and debris*: desquamated epithelial cells, white blood cells, oral bacteria, food debris, gingival crevicular fluid. This mixture makes saliva a fluid that “reflects” oral and systemic health.

In summary, saliva acts as a “medium” for lubrication, antimicrobial defense, initial digestion, acid–base buffering, and protection of enamel and oral tissues (de Almeida Pdel V et Al, 2008).

The pH of saliva is influenced by various factors: ionic composition, salivary flow, stimulation, eating habits, microbiology, and systemic conditions.

The “normal” pH of saliva has been reported to be around 6.2-7.6 in healthy individuals.

The study “Physiological regulation of oral saliva ion composition and flow rate are not coupled in healthy humans” found that unstimulated saliva was more “acidic” (lower pH) and that stimulation increased flow, pH, and HCO_3^- bicarbonate concentration (Schwerdt G et al., 2025).

Certain factors influence salivary pH:

- *Salivary flow*: when saliva is stimulated (e.g., chewing), flow increases and often bicarbonate also increases, pushing the pH toward more alkaline values.
- *Salivary buffering capacity*: the presence of HCO_3^- , phosphates, and buffering proteins helps neutralize acids produced by diet or bacteria.
- *Ionic composition*: for example, phosphate and calcium levels influence enamel chemistry and local pH.
- *Oral microbiome and acid production*: cariogenic bacteria produce acids (such as lactic acid), lowering the pH; one study showed that salivary pH and iron concentration influence the structure of the oral microbiota (Zhou J, et al., 2017).
- *Food stimuli/external acids*: acidic foods and beverages temporarily lower pH, while saliva attempts to return to neutrality. The study “Effect of Saliva on pH in Different Regions of the Mouth” shows how saliva modulates pH at different points in the mouth after stimulation with citric acid.
- *Systemic conditions/oral hygiene/age*: for example, in fixed orthodontic treatments, one study observed that stimulated saliva increases pH, but unstimulated saliva can decrease pH during treatment.

When saliva pH drops to around 5.5 or below, the critical threshold for enamel demineralization is reached (Suresh C et al., 2022).

Saliva represents a first line of defense: good flow and a higher pH are associated with a lower risk of tooth wear.

Saliva is a rich and complex fluid with key physiological functions for oral and systemic health. Its pH is determined by a combination of factors: salivary flow, buffering capacity, ionic composition, microbial activity, and external stimuli. Maintaining it within a favourable range is important for protecting teeth and oral tissues.

Recent studies emphasize that the buffering capacity of saliva (i.e., its ability to neutralize acids) and higher pH are associated with less tooth wear or erosion. For example, in a study of university students, a negative correlation was observed between lower stimulated pH and higher BEWE (dental erosion index) scores (Nombre et al., 2025).

Another study states that when salivary pH drops to 5-5.5, there is already a risk of enamel demineralization (Suresh et al., 2022).

A study of 159 patients showed that lower saliva pH values (stimulated or unstimulated) were associated with greater tooth wear, even when age and gender were considered (Madariaga VI et al., 2025).

In individuals with gastroesophageal reflux disease (GERD), continuous exposure to gastric acids in the mouth alters saliva (flow, buffering capacity) and promotes dental erosion (Filipi et al., 2011).

In another study on patients with diabetes mellitus, it was found that the average salivary pH values were significantly lower than in the control group, and these more acidic values were correlated with

a higher incidence of caries and gingivitis (Seethalakshmi C et al., 2016).

Therefore, chronically low salivary pH may represent both an increased risk of caries and an increased risk of enamel erosion.

All of this suggests that having overly acidic salivary pH may signal an imbalance in the mouth's protection against chemical, bacterial, or mechanical agents, and therefore may serve as a preventive signal.

The main ways to monitor salivary pH are:

- Use of pH test strips (litmus paper): this is a simple method, available at pharmacies. Saliva is collected (ideally on an empty stomach, or under standard conditions) and the strip is applied, which changes color depending on the pH.
- Measurements using digital laboratory or chair-side instruments in dental practices (saliva pH meter) used in clinical settings. For example, a digital meter was used in a study of diabetic patients (Seethalakshmi C et al., 2016).
- In research contexts: sampling of “stimulated” and “unstimulated” saliva with measurements of salivary flow, buffer capacity, and pH (Nombre et al., 2025).

The recommended procedures for reliable measurement are:

- Avoid food or drink (especially acidic) for at least 1-2 hours before the test.
- Avoid brushing your teeth a few minutes before the test (it can alter the values).
- If using litmus paper, follow the manufacturer's instructions for color reading and timing.
- Record the data along with the time of day and conditions (e.g., 2 hours after a meal, fasting) for context.

Since saliva is strongly influenced by diet, oral hygiene, bacterial microenvironment, and salivary flow, the best strategies for promoting a more balanced (less acidic) pH may be:

a. Food and beverages

Reduce consumption of acidic beverages (soda, wine, citrus juices) that quickly lower salivary pH. For example, a follow-up study after exposure to Coca-Cola found that the minimum salivary pH was approximately 6.3 and required ~27 min for recovery (Polyakova M et al., 2024).

Promote a diet that includes vegetables, less acidic fruits, water, and limit simple sugars that feed acid-producing bacteria.

b. Improve buffering capacity and salivary flow

Salivation can be stimulated by chewing sugar-free gum, drinking water, and avoiding dry mouth. Increased salivary flow helps dilute acids and restore pH.

You can also use oral products that increase pH or improve buffering capacity: for example, the study “Effect of Oral Care Foams and a Spray on Salivary pH” evaluated the use of alkaline sprays/foams after acidic drinks to accelerate pH recovery (Polyakova M et al., 2024).

c. Oral hygiene and lifestyle

It is essential to maintain good oral hygiene: remove plaque and reduce food residues that bacteria convert into acids.

Manage gastroesophageal reflux as best as possible: since gastric acid that rises alters the pH of saliva and promotes dental erosion, treating reflux conditions can help stabilize oral pH (Corrêa MC et al., 2012).

Finally, avoid habits that promote oral acidity: smoking, frequent consumption of acidic snacks,

poor oral hygiene.

d. Routine and monitoring

Measure salivary pH regularly (e.g., in the morning before breakfast, after meals) to understand trends.

It is also important to associate this with behavioural changes: when a patient sees that after an acidic meal the pH remains low for a long time, they can intervene by reducing that type of meal or drink.

Although there are correlations between low salivary pH and dental/oral problems, causality is not always established: many factors influence oral health (salivary flow, bacterial composition, hygiene, overall diet). For example, the study on GERD found no significant difference in salivary pH between groups, but did find a difference in buffering capacity (Corrêa MC et al., 2012).

Salivary pH is a local indicator of the mouth and should not be confused with the body's systemic acid-base balance or other general health parameters.

Measurements with “consumer” pH strips in uncontrolled settings may vary and should be interpreted with caution.

The importance of monitoring salivary pH is all the more relevant when the subject has a high predisposition to the onset of carious lesions.

The causes of susceptibility to carious lesions (dental caries) are multifactorial, i.e., they depend on several factors acting in synergy. The main ones are:

1. A diet rich in fermentable sugars

Simple sugars (sucrose, glucose, fructose) are metabolized by bacteria in the oral cavity, producing acids that lower the pH and demineralize tooth enamel (Kirthiga M et al., 2019).

Frequent consumption throughout the day increases the time of exposure to acidity (Kılınç G, et al., 2015).

2. Presence of cariogenic bacteria

The main culprits are *Streptococcus mutans* and *Lactobacillus* spp., which are capable of producing acids from sugars (Kirthiga M et al., 2019). An altered oral flora promotes the adhesion of these bacteria to tooth surfaces.

3. Reduced salivation or low-quality saliva

Saliva protects teeth thanks to its buffering capacity, mechanical removal of residues, and antibacterial enzymes (Cunha-Cruz J et al., 2013). Xerostomia (dry mouth) is therefore a major risk factor.

4. Acidic salivary pH

A salivary pH below 5.5 promotes enamel demineralization and caries formation (Aranibar Quiroz EM et al., 2014).

5. Inadequate oral hygiene

Unremoved plaque leads to bacterial proliferation, resulting in increased acid production and thus the onset of caries.

Insufficient brushing or incorrect use of dental floss contributes to plaque formation (Ng, TC-H et al., 2024).

6. Unfavourable dental anatomy

Very deep grooves or closely spaced teeth promote the accumulation of plaque and food debris, making cleaning difficult (Zhang J et al., 2019).

7. Genetic factors

Genetics can also influence saliva composition, enamel structure, immune response, and bacterial susceptibility.

8. Age and systemic conditions

Children and the elderly often have a higher incidence of caries for different reasons (diet, poor hygiene, reduced saliva).

Patients with diabetes, autoimmune diseases, or drug treatments generally have more serious oral problems.

When the salivary pH is too alkaline (above 7.5-8.0), we may have:

- Alteration of the oral bacterial flora: an overly alkaline environment can promote the growth of less typical bacteria and decrease 'normal' bacteria, leading to oral dysbiosis.
- Increased precipitation of mineral salts in plaque (tartar): a higher pH can promote plaque calcification and thus tartar formation, which can contribute to gingivitis/periodontitis.
- Potential increase in halitosis: bacteria that thrive in alkaline environments can produce malodorous compounds (which produce sulfur compounds, e.g., ammonia).
- Saliva has less buffering capacity when the system is out of balance: despite high pH, saliva may be less protective if its composition is altered.

Digestive difficulties: in some cases, alkalinity may reflect systemic imbalances.

Possible causes may include:

- Oral infections (e.g., advanced periodontitis): anaerobic bacteria produce ammonia, which raises the pH.
- Excessive intake of alkalizing substances (supplements, diets too rich in bicarbonate or alkaline vegetables).
- Reduced salivary function or dry mouth: less salivary flow can increase pH.
- Vomiting or chronic reflux: saliva becomes alkaline to neutralize gastric acidity.
- Systemic diseases: such as Sjögren's syndrome or certain kidney conditions.
- Reduced salivary flow or impaired salivary gland function results in less diluted saliva with fewer buffers, which can lead to base accumulation.
- Increased ammonia production by bacteria that metabolize urea/arginine in plaque causes an increase in local pH (Marcotte H, Lavoie MC., 1988).
- Systemic or metabolic changes (e.g., chronic vomiting, kidney problems, use of basic or alkalizing supplements) that can affect oral pH (although there is little specific data).
- Unrestricted use of highly alkaline products (mouthwashes, toothpastes) can temporarily contribute to an increase in salivary pH.

Salivary pH measurement is most meaningful when performed under standardized conditions, i.e., at times when it is not influenced by external factors such as food, drink, or recent oral hygiene.

The ideal time for measurement is in the morning upon waking, before eating or brushing your teeth.

This is when saliva best reflects the internal state of the body, without temporary interference.

Other recommendations are to perform the salivary pH assessment:

- On an empty stomach, at least 2 hours after your last meal or drink.
- After rinsing with water, if you have already eaten.

- Avoid testing immediately after intense exercise or emotional stress (both of which can temporarily alter pH).
- In case of frequent monitoring (e.g., for apps or studies), always use the same time each day for consistent comparison.

Otherwise, for clinical use or self-monitoring, as in the case of this study, it is good to monitor salivary pH:

- Early in the morning (before breakfast) for a baseline assessment.
- After meals (e.g., 60-120 min) to observe the buffering capacity of saliva.
- Before bedtime (useful in patients with xerostomia or reflux).

2.3.1 Limitations of Salivary pH as a Oral Health Indicator

Salivary pH can be a useful contextual parameter in oral health research and screening, but it is not a definitive diagnostic marker on its own. Due to its high intra-individual variation, low specificity, and measurement challenges, salivary pH should be interpreted alongside other clinical measures and biomarkers for a reliable assessment of oral health.

1. Salivary pH is highly variable and influenced by many external factors

Salivary pH is affected by environmental and individual factors such as diet, time of sampling, salivary flow rate, hydration status, and oral hygiene habits. Because of this, a single pH measurement can be unreliable as a stable indicator of oral health.

Salivary pH “differs extensively based on several factors” including diet and bacterial activity, which can change rapidly throughout the day. Hence measurements are not stable and vary with time and conditions (Sabbar HA et al, 2025).

Unlike controlled clinical biomarkers, saliva composition and pH fluctuate with stimuli like chewing, which can alter pH and flow rate significantly (Li Y et al, 2024).

2. Salivary pH alone lacks specificity and diagnostic power

While altered salivary pH correlates with certain conditions (e.g., low pH with caries risk), pH by itself cannot differentiate between disease states or provide a comprehensive overview of oral health:

a. Oral health status is better predicted by multiple salivary biomarkers (proteins, enzymes, inflammatory markers) rather than pH alone. A study found that combinations of salivary biomarkers had much higher predictive accuracy for gingivitis and periodontitis than single markers would (Bostanci N et al , 2021).

b. Changes in salivary pH do not directly indicate specific oral diseases without context from other clinical measures and biomarkers (Bostanci N et al , 2021).

3. The pH range of saliva is broad and often overlaps between health and disease

Healthy individuals can display a wide normal range of salivary pH (e.g., ~6.2–7.6), making it hard to establish clear thresholds for disease:

Normal saliva pH varies widely; individuals with salivary pH values at either end of this range may still be clinically healthy (Kurien V et al, 2024).

Because of this natural variability, salivary pH alone lacks the specificity needed for clinical classification of oral health versus disease.

4. Salivary pH changes may be secondary rather than causative

Salivary pH may reflect secondary effects of oral disease processes rather than being a direct causal or primary marker. For example, periodontal disease severity has been associated with lower salivary flow and lower pH, but these changes may result from altered gland function and inflammation rather than pH being a direct marker of disease (Lăzureanu PC et al, 2021).

Altered salivary pH can be a consequence of disease rather than a reliable cause-oriented indicator

5. Traditional measurement techniques lack precision

Commonly used methods for measuring salivary pH (e.g., pH strips) often suffer from limited

precision and reproducibility, which further weakens their clinical reliability:

Simple pH indicator strips, while cost-effective, are recognized as being more prone to error and contamination than digital or laboratory methods (Vacarel EV et al, 2025).

Inaccuracies in measurement can lead to misinterpretation of pH values.

3. CONSEQUENCES OF HYPERACIDITY IN THE BODY

3.1 Infections and Inflammation

Local or systemic acidification creates an environment that can stimulate inflammatory activity (e.g., through the NLRP3 inflammasome) and alter immune function (macrophages, neutrophils). This can make the body more vulnerable to infections or promote an excessive or chronic inflammatory response. However, it is important to note that the pH of blood and tissues is tightly regulated, and that much of the evidence relates to microenvironments or pathological conditions rather than the entire healthy body.

In an in vitro study on human macrophages, it was shown that an acidic extracellular environment (pH 6–7.5) activates the NLRP3 inflammasome complex and promotes the secretion of IL-1 β , one of the main pro-inflammatory mediators (Rajamäki K, 2013). According to this study, “acidic extracellular pH triggers pH-dependent IL-1 β secretion and caspase-1 activation via NLRP3.” Extracellular acidosis may be a “danger signal” that activates the innate immune system (Rajamäki K, 2013).

A review entitled “Extracellular acidosis and the immune response: clinical and physiologic implications” highlighted that conditions of metabolic or tissue acidosis alter immune function and the production of inflammatory mediators and can compromise the response to infection (Kellum JA et al., 2004). The article states that “acidosis itself has profound effects on the host, particularly in the area of immune function.”

Another review, “The Acid-Base Balance and Gender in Inflammation: A Mini-Review,” reports that acid-base balance abnormalities (e.g., acidosis) are observed in numerous inflammatory processes and suggests that pH may modulate immune response and infectious vulnerability (Casimir GJ et al., 2018).

The study “Intracellular acidification and glycolysis modulate inflammatory pathway in senescent cells” showed that intracellular (not just extracellular) acidification in senescent cells promotes the expression of inflammatory genes and a state of “senescence-associated secretory phenotype” (SASP). This suggests that acidification conditions at the microcellular level can generate a state conducive to chronic inflammation (Satoshi Kawakami, 2024).

A more acidic extracellular or intracellular environment can alter the function of immune cells: for example, in neutrophils, extracellular acidification increased activation, signal release, and delayed apoptosis (Trevani AS et al., 1999).

In macrophages, a reduction in external pH causes a reduction in intracellular pH and promotes the formation of the NLRP3 inflammasome, leading to increased production of IL-1 β and other inflammatory mediators.

Tissue acidosis can promote a state of damage associated with inflammation and barrier impairment (e.g., in ischemia or chronic inflammation). This condition facilitates the entry or persistence of pathogens or a prolonged inflammatory response (Rajamäki K, 2013).

An increase in systemic (or local) acid load can therefore compromise buffer functions, alter the cellular environment, and promote conditions in which pathogens find more favorable ground or the immune response is altered.

3.2 Increased body weight

A food is defined as acidifying if, after metabolism, it generates a positive Potential Renal Acid Load (PRAL). For example, red meat, aged cheeses, and refined cereals all have a positive PRAL and are therefore acidifying. Vegetables, fruits, and tubers have a negative PRAL and are therefore alkalizing.

According to the theory of adipose tissue accumulation as protection (Frassetto et al., 2001), a chronic excess of metabolic acids would cause the body to use minerals (e.g., calcium, magnesium) to buffer and accumulate toxins and acids in adipose tissue to protect vital organs. This mechanism could contribute to fat accumulation as a compensatory response.

As a defensive strategy, the body creates lipocytes to remove acids from vital organs that need to be protected. When alkalizing foods are consumed, the body will no longer need to store excess fat.

More generally, if the body is overloaded with a chronic excess of metabolic acids, the liver is subjected to additional stress that complicates and slows down the effective metabolization of fats and sugar.

The chaos in an unbalanced body will wear down the adrenal glands. The resulting drop in energy levels will contribute to weight gain.

Another likely drawback is fatigue of the thyroid gland, which controls the speed of metabolism. Cravings for acidifying foods such as sweets, excessive appetite, and low blood sugar levels are all consequences of dietary and metabolic acids. Taken together, these conditions make it easier to gain weight and more difficult to lose weight.

Finally, conditions of indigestion and possible depression will manifest or worsen.

An acidifying diet is often a high-calorie diet. Many acidifying foods are also high in calories (e.g., processed meat, cheese), low in fiber, and low in micronutrients. This facilitates weight gain due to excess energy and not acidity itself.

A chronic excess of acid load can also strain kidney function and negatively affect metabolism, even altering the hormonal signals related to hunger/satiety (leptin, ghrelin) .

A meta-analysis showed that a high dietary acid load (high Potential Renal Acid Load - PRAL or Net Endogenous Acid Production - NEAP) is associated with a higher prevalence of obesity and higher triglyceride levels. “Higher dietary acid load content ... was associated with higher serum triglyceride concentrations ... and higher obesity prevalence (30% and 27% in highest versus lowest categories).” In the female subgroup, high PRAL was associated with an increase in BMI (WMD: 0.122; CI: -0.001 - 0.245; P = 0.049) (Abbasalizad Farhangi M et al., 2019).

A cross-sectional study of 6,482 participants examined the link between dietary acid load (DAL) and abdominal obesity. Higher DAL values were found to be significantly associated with an increased risk of central obesity (particularly in women). However, the association with PRAL was not significant in the fully adjusted model (“higher levels of DAL were related to increased odds of central obesity based on WC, WHR, and AVI across all models.”) (Abdollahpour, N et al., 2025).

Another study on young adults (346 students) showed that in subjects with low adherence to the Mediterranean diet and high consumption of ultra-processed foods, high PRAL and NEAP were correlated with abdominal obesity: “In subjects with MedDietScore ≤ 28.00 ... PRAL and NEAP were negatively associated with 1/WC ... suggesting PRAL/NEAP related to central obesity.” (Detopoulou P et al., 2023).

Finally, a study of Iranian children and adolescents showed a direct association between NEAP (and partly PRAL) and certain anthropometric indices (e.g., neck circumference) but not always with BMI: “there was a significant association between NEAP and NC (neck circumference)” (Aslani Z et al., 2021).

A diet with a high acid load (high animal protein, phosphates, few vegetables) leads to a metabolic state that can increase insulin resistance. The study “Dietary acid load, metabolic acidosis, and insulin resistance” showed that an increase in PRAL/NEAP is associated with worse insulin sensitivity.

There are various mechanisms that explain how a high dietary acid load can promote weight gain.

First, insulin resistance: high chronic metabolic acidity can promote a low-grade inflammatory

response and alterations in insulin sensitivity, promoting fat accumulation (Ostrowska J et al., 2020).

High-acid diets are linked to increased secretion of stress hormones (e.g., cortisol), which can stimulate lipogenesis and fat accumulation, thus maintaining a state of chronic inflammation (Ostrowska J et al., 2020).

A high acid load can induce bone mineral loss, alter muscle mass, and potentially decrease basal metabolism, promoting weight gain and thus altering bone and muscle metabolism (Ostrowska J et al., 2020).

Finally, high PRAL diets are often rich in animal protein and low in fiber, fruit, and vegetables—elements that can directly influence calorie intake, satiety, and body composition (Mansordehghan, M. et al, 2022).

In contrast, a clinical study ("Dietary acid load on the Mediterranean and a vegan diet: a secondary analysis of a randomized, cross-over trial") showed that a low-acid vegan diet led to a reduction in body weight of about 6 kg compared to a Mediterranean diet, and that the related reductions in PRAL/NEAP were associated with weight loss even after controlling for energy intake (Kahleova H et al., 2025).

In fact, according to the guidelines, the recommendations for reducing the risk of overweight, reducing the acid load in the diet, and potentially promoting weight control are to

- Increase consumption of vegetables in large quantities, fresh fruit, and legumes: these foods tend to have a negative PRAL (alkalizing).
- On the other hand, reduce the consumption of foods with high PRAL: red meat, aged cheese, refined grains, and excessive animal products.
- Choose whole grains in moderation and prefer pseudocereals (e.g., quinoa, millet) if compatible with the diet.
- Maintain a good intake of water and fiber, which aid in metabolism and elimination.
- Monitor total energy intake: although low PRAL is beneficial, energy restriction or overall dietary quality remain decisive for body weight.
- Integrate physical activity and an active lifestyle: research shows that acid load is only one of the factors that influence weight and body composition.

There is therefore growing evidence that a diet with a high dietary acid load (high PRAL/NEAP) is associated with higher BMI, fat mass, and waist circumference values. The strongest link with weight gain has not yet been fully demonstrated, but biological mechanisms suggest that a chronic acidic environment may promote metabolic, inflammatory, and compositional changes that lead to the accumulation of body fat.

3.3 Allergies

Food allergies, as reactions to certain acidic foods, cause obvious symptoms: from abdominal pain to skin rashes, itching, and swelling. Many people affected by these reactions (or other more subtle ones) attribute their symptoms to other causes.

High-acid diets can promote low-grade inflammation and alter the immune balance (e.g., activation of immune cells, increase in inflammatory mediators). This could promote sensitization or worsen an allergic response.

In addition, a high acid load can affect kidney function or the ability to eliminate metabolites (acids) which, if accumulated, could modulate the tissue microenvironment and promote an altered immune response.

Diets with high PRAL are often rich in animal protein and phosphorus and low in fruit and vegetables: such dietary profiles are already associated with worse immuno-metabolic outcomes and

could indirectly increase the risk of allergies or allergic inflammation.

In a study that analysed the association between dietary acid load and the severity of the autoimmune skin disease Pemphigus Vulgaris, a positive relationship was found between high PRAL/NEAP values and PV severity (Fallah M et al, 2024).

A more comprehensive review of dietary acid load (“Pflügers Archiv – European Journal of Physiology,” 2024) reports that high-acid diets are associated with systemic inflammation and immune dysfunction (Wieërs MLAJ et al, 2024).

However, a study of women with bacterial vaginosis (vaginal infection) found no significant association between dietary acid load and BV (Noormohammadi M et al, 2022).

Another study on mood disorders and acid load in children/adolescents (in allergy contexts) did not directly analyse allergies as an outcome: the study “Dietary Acid Load and Mental Health Outcomes in Children and Adolescents” (GINIplus & LISA cohorts) reports effects on mental well-being, a condition that can coexist with allergies, but this is not direct evidence (Bühlmeier J et al, 2018).

According to systematic reviews, the foods that cause most food allergies are:

- Cow's milk
- Hen's egg
- Peanuts
- Tree nuts
- Fish and shellfish
- Soy
- Wheat
- Sesame (Chafen JJS et al, 2010; Han Y et al, 2012)

The study “Diagnosing and Managing Common Food Allergies: A Systematic Review” states that milk, eggs, peanuts, tree nuts, fish, and shellfish account for more than 50% of all food allergies (Chafen JJS et al, 2010).

Another study specifies that “egg, milk, peanut, tree nut, fish, shellfish, soy, and wheat” account for over 90% of major food allergens (Han Y et al, 2012).

There are many causes.

Foods contain proteins that resist digestion and are not completely broken down in the stomach/intestines, thus maintaining epitopes recognized by the IgE-mediated immune system. In fact, the study “Food allergy -JCI” explains that the main food allergens belong to a few stable protein families, and that their three-dimensional structure allows them to bind with IgE (Wang J, Sampson HA, 2011). The review “Allergen Stability in Food Allergy: A Clinician's Perspective” also emphasizes that the stability of the protein during food processing (heat, digestion) is a factor that increases allergenicity (Koidl, L et al, 2023).

In some foods, certain proteins share similar sequences or structures across food species (cross-reactivity), facilitating sensitization. The JCI paper cites that many allergenic foods contain sequential or conformational epitopes that allow for immune reaction (Wang J, Sampson HA, 2011).

Furthermore, the way a food is processed (cooled, heated, fermented) can alter its protein structure and allergenicity. The review “Food processing and allergenicity” indicates that some processes do not abolish allergenicity and in some cases can accentuate it (Verhoeckx KCM et al, 2015).

Some of the foods mentioned above are widely consumed in infant diets or in the family, increasing the likelihood of sensitization, given their early introduction and high dietary exposure. Examples include milk and eggs in infancy (Prescott, S.L., et al, 2013). The prevalence of allergens varies by region depending on the local diet: in Europe, milk and eggs are very common in children (Burney PG et al, 2013).

Conversely, other hypotheses suggest that a lack of early exposure or late introduction of a food allergen may increase the likelihood of sensitization (the “hygiene hypothesis”). This ties in with the point about high exposure.

Another study specifies that "egg, milk, peanut, tree nut, fish, shellfish, soy, and wheat" account for over 90% of important food allergens (Han Y et al, 2012).

3.4 Chronic Fatigue Syndrome, CFS, or Myalgic Encephalomyelitis ME/CFS

CFS is defined as persistent or relapsing fatigue of at least 6-months' duration, that is not alleviated by rest, and that causes substantial reduction in activities. The fatigue cannot be explained by medical or psychiatric conditions and must be accompanied by at least 4 of 8 case-defining symptoms (unusual post-exertional fatigue, impaired memory or concentration, unrefreshing sleep, headaches, muscle pain, joint pain, sore throat, and tender cervical nodes).

The estimated prevalence varies (0.2-0.7% or even more in some analyses) in the general population (Maquet D et al, 2006).

In addition to severe fatigue that cannot be explained by other causes, other frequently associated symptoms include (according to systematic review): post-exertional malaise, unrefreshing sleep, cognitive problems (concentration, memory), muscle or joint pain, headaches, recurrent sore throat, or tender lymph nodes (Clauw DJ., 2010).

The diagnosis is clinical, based on criteria (e.g., CDC/Fukuda criteria) and the exclusion of other diseases (Afari N, Buchwald D., 2003).

The exact cause of CFS is not yet fully understood. Studies suggest a multifactorial nature:

- Immune alterations: for example, a systematic analysis found abnormalities in T lymphocytes, cytokine levels, and reduced NK (natural killer) cell activity in some studies (Lyall M et al, 2003).
- Neuroendocrine and autonomic nervous system dysfunction: altered regulation of the hypothalamic-pituitary-adrenal (HPA) axis in some patients (Moss-Morris R et al, 2013).
- Metabolic and muscular disorders: emerging evidence indicates reduced mitochondrial capacity and altered energy metabolism in muscle fibers in patients with ME/CFS (Wang X et al, 2023).
- Precipitating factors: sometimes the onset is after viral infection, physical or psychological stress (Afari N, Buchwald D., 2003).

An acidifying diet may promote feelings of chronic fatigue, as a high acid load requires greater effort from the buffer, renal, and respiratory systems to maintain acid-base balance. This additional “metabolic effort” could contribute to feelings of fatigue. In conditions of increased acidity, muscle cells may find themselves in an environment that is less conducive to oxygen transport, efficient energy production, and recovery during exercise. The exercise study shows that exhaustion time is shorter on a high PRAL diet (Caciano SL et al, 2015). In addition, a high-acid diet is associated with mild systemic inflammation and worsening metabolic parameters (insulin resistance, etc.), which in turn can contribute to chronic fatigue (Ostrowska J et al, 2020).

A study on subjects with multiple sclerosis (MS) evaluated the association between DAL (calculated using PRAL and NEAP) and fatigue (fatigue severity scale). It found that, although there was some correlation, the association between DAL and fatigue was weak and inconsistent (Saul A et al, 2023).

In a study on the effect of dietary acid load on physical performance, it was found that a ‘less acidifying’ diet (low PRAL) led to a longer time to exhaustion in anaerobic exercise, suggesting that a higher acid load may be associated with greater muscle fatigue during physical exertion (Caciano SL et al, 2015).

Dietary acid load may be one of many factors contributing to fatigue. Other factors (total calories, sleep quality, physical activity levels, nutrient deficiencies, underlying diseases) play an obvious role in chronic fatigue.

3.5 Mood disorders and neurological imbalances

There is a significant association between high dietary acid load (measured by PRAL/DAL/NEAP) and an increased risk of depression and, to a lesser extent, anxiety.

It is plausible that mechanisms such as inflammation, disturbed sleep, poor food choices, and compensatory efforts by the body are behind this link.

A direct causal relationship has not yet been clearly demonstrated, and the precise contribution of “acid load” compared to other factors remains to be clarified.

The effect varies depending on gender, age, and medical conditions (Bahari, H et al., 2023).

Dietary acid load may be a marker of an overall less healthy diet rather than an isolated factor.

Other factors (genetics, environment, level of physical activity, sleep quality, environmental exposures) play a critical role in mood and neurological disorders.

Possible correlations between a diet high in acidifying foods and an overall reduction in pH may be as follows. High-acid diets are associated with elevated inflammatory markers, and chronic inflammation is known to affect mood and brain function. Prolonged disruption of tissue acid-base balance may also occur: a body that constantly supports a high acid load may require greater buffer/renal compensation, which could affect metabolic and brain function, with possible impacts on energy, concentration, and humoral regulation.

Mood disorders are also linked to the quality of the sleep/wake balance: studies suggest that a high PRAL/DAL is related to poorer sleep quality. Insufficient or poor-quality sleep is a strong risk factor for mood disorders (Mahjourian MM et al, 2025).

Finally, metabolic dysfunction may occur: an acidifying diet tends to be associated with less healthy food choices (more animal protein, less fruit/vegetables) that can affect brain nutrition, mitochondrial function, and neuronal metabolism, potentially predisposing to neurological imbalances.

3.6 Type 2 diabetes (T2D)

A diet with a high acid load (high PRAL/NEAP), often characterized by higher consumption of animal protein, refined grains, phosphates, and lower consumption of fruits/vegetables, is associated with an increased risk of type 2 diabetes.

The main mechanisms include insulin resistance, metabolic alterations, and deficiency of alkalizing minerals. However, this does not mean that it is the sole cause, and the effect must be considered in the context of overall lifestyle.

High dietary acidity may promote insulin resistance: a Danish study of 54,651 individuals (Population-based studies of relationships between dietary acidity load, insulin resistance, and incident diabetes in Danes) showed that high PRAL scores were associated with reduced insulin sensitivity (e.g., Matsuda index) and an increased risk of T2D (HR ~1.24 between the 1st and 5th quintiles) (Gæde J et al, 2018).

Alkalizing nutrients—such as potassium and magnesium—come mainly from fruits and vegetables and help maintain acid-base balance. Diets low in these minerals and high in animal proteins/phosphates (typical of high-PRAL diets) can alter metabolism and promote β -cell dysfunction and insulin resistance (Abshirini, M et al, 2019).

Another study, "The dietary acid load is higher in subjects with pre-diabetes who are at greater risk of diabetes: a case-control study," showed that subjects with prediabetes had significantly higher PRAL and NEAP scores than controls, suggesting that high dietary acid load may be related to insulin resistance and risk of T2D (Abshirini, M et al, 2019).

Not all studies show the same intensity of association, and in some cases the effect varies by gender or age (for example, a Japanese study found an association in men only) (Akter S et al, 2019).

The association is statistical: causality (i.e., that dietary acid load alone causes diabetes) has not been fully proven.

There are many confounding factors: overall diet quality, physical activity, obesity, genetic predisposition, etc.

It is likely that dietary acid load is a modulating factor and not the sole risk factor.

Diabetics have low or normal blood sugar levels when their pH (as measured by urine) is high (alkaline, above 7.2), and they have high blood sugar levels when their pH is low (acidic, below 7.2).

Type 2 diabetes is the natural and physiological result of consuming enormous amounts of sugar, refined carbohydrates, and animal protein, especially in the absence of regular physical activity (which could help compensate for such dietary behaviours).

Research has shown that, in the case of diabetes, even a single dose of sugar can cause changes in the body, even at the genetic level, increasing the risk of diabetes complications. Even short-term exposure to sugar has long-term effects on the body's cells. In a study of diabetic mice, cells showed the effects of a single dose of sugar for up to 2 weeks afterwards. The anatomical effects of sugar go beyond the mere response to a snack or meal, affecting the body's natural metabolic capacity.

This means, among other things, that the solution is quite simple: eliminate all forms of sugar, exclude animal proteins, and exercise regularly.

3.7 Hypercholesterolemia

If the body is hyperacid, meaning that there are too many acids to be eliminated through urination, sweating, defecation, and breathing, the body goes into preservation mode and, in order to protect itself from the toxic effects of acids, releases cholesterol from the liver to buffer them. Although it is considered harmful, cholesterol exists to help us.

A diet with a high acid load can be associated with worsening lipid profiles (increased total cholesterol, LDL, worse lipid ratio) and thus contribute to the risk of hypercholesterolemia.

Plausible mechanisms include metabolic stress, inflammation, lower intake of alkaline nutrients, and insulin resistance.

In relation to increased metabolic stress and increased cellular acidity, it has been shown that a diet that produces a higher acid load can induce a state of mild tissue acidosis or metabolic compensation (e.g., increased ammonium production, increased bicarbonate uptake), which can alter lipid metabolism by activating enzymes that promote lipogenesis. For example, an animal study showed that induced acid load increased hepatic triglyceride synthesis (Høstmark, A.T et al, 2013).

High PRAL diets are associated with low-grade systemic inflammation and impaired endothelial function. Chronic inflammation can alter lipoprotein metabolism, increase LDL oxidation, and impair cholesterol clearance.

In addition, an acidifying diet tends to contain fewer fruits, vegetables, and alkalizing micronutrients or buffer minerals (calcium, magnesium, potassium). Deficiency of these minerals can affect lipid metabolism, mitochondrial function, and the ability to break down or transport lipids.

Finally, it is important to note that high dietary acid load has also been associated with insulin resistance, and insulin resistance alters cholesterol metabolism: it increases hepatic VLDL production, reduces LDL clearance, and worsens the overall lipid profile.

A study of Japanese women showed that a high PRAL score was associated with higher total cholesterol and LDL-cholesterol values (Murakami K et al, 2008).

A study of patients with type 2 diabetes showed that higher NEAP/PRAL levels were associated with a worse lipid profile (total cholesterol, LDL, LDL/HDL ratio) in the presence of a particular gene polymorphism (CETP Taq1B) (Abaj, F et al, 2023).

An updated meta-analysis showed that a high dietary acid load is associated with worse cardiometabolic indicators, including lipid alterations (Dolati S et al, 2024).

It cannot be stated with certainty that an acidifying diet alone causes hypercholesterolemia, as studies showing associations are often cross-sectional or in specific populations (diabetics, the elderly, women). Dietary acid load could be considered a marker of an overall less healthy diet (high consumption of meat, cheese, refined cereals; low consumption of fruit/vegetables) rather than the sole factor. Lipid alterations have many risk factors: genetic, lifestyle, physical activity, smoking, body weight, age, etc. Acid load may be one factor among many.

3. Osteoporosis

Osteoporosis is a skeletal disease characterized by bone loss, deterioration of bone microarchitecture, and a consequent increase in bone fragility and risk of fractures.

Bones become less dense and more porous, which reduces their ability to withstand loads and trauma (Mirzababaei A et al, 2025).

Postmenopausal women, the elderly, people with insufficient calcium/vitamin D intake, physical inactivity, and genetic factors are particularly at risk.

A diet with acidifying foods may predispose to osteoporosis.

The proposed mechanisms and evidence from the literature suggesting that a diet rich in acidifying foods may predispose individuals to osteoporosis are:

a) Dietary acid load and bone balance

The so-called “acid-ash hypothesis” (a diet rich in acid residues after metabolism) suggests that a diet rich in animal proteins, refined cereals, phosphates, and low in fruit/vegetables (and therefore bases) increases the endogenous acid load, causing the body to resort to bone “buffers” (e.g., calcium from the skeleton) to neutralize the acidity.

However, the evidence is not conclusive: a meta-analysis found that, although calcium excretion in urine increased, there was no solid evidence that this led to a negative calcium balance or bone loss in healthy people (Tanis R et al, 2009).

Nevertheless, a cross-sectional study of postmenopausal women found that higher dietary acid load (PRAL/NEAP) values were associated with an increased likelihood of osteoporosis (Farshbaf-Khalili A et al, 2022).

b) Epidemiological evidence

A study of the EPIC-Norfolk cohort showed that high PRAL values were associated with an increased risk of bone fractures in adults (HR approximately 1.21-1.33 for the highest quintile) in an analysis of over 25,000 individuals (Hayhoe RPG et al, 2020).

A 2025 systematic review and meta-analysis evaluated six studies on the association between dietary

acid load and fractures: in good-quality cohort studies alone, the association was significant (HR ~1.12; 95% CI 1.03-1.22) for higher acid load (Mirzababaei A et al, 2025).

However, another study (PIVUS) of older adults found no significant association between PRAL/NEAP and bone mineral density or fractures (Jia T et al, 2015).

c) Other associated factors

High-acid diets tend to be low in alkalizing minerals (potassium, magnesium, calcium) that are essential for bone health. In a study of postmenopausal women with osteoporosis, the group with osteoporosis had significantly lower intake of potassium, magnesium, and calcium (Farshbaf-Khalili A et al, 2022).

The kidney's ability to manage excess acid may decline with age; reduced kidney function may amplify the potentially harmful effects of a high acid load on the skeleton (Mirzababaei A et al, 2025).

Not all studies fully support the hypothesis that dietary acid load causes osteoporosis: as mentioned, the 2011 meta-analysis concluded that there was no evidence of acid load-related bone loss in healthy adults (Fenton TR et al, 2011).

The associations vary in subgroups: in some studies, the effect only emerges when calcium intake is low, or in postmenopausal women (McLean RR et al, 2011).

Many factors influence bone health: level of physical activity, smoking, alcohol consumption, vitamin D, hormones (e.g., estrogen), genetics. Acid load is only one aspect.

The direct mechanism linking an acidifying diet with a significant increase in acidaemia and consequent mobilization of bone calcium has not been conclusively demonstrated in human models.

A diet with a high dietary acid load (more acidifying foods, fewer alkalizing foods) may be associated with poorer bone health (reduced bone density, risk of fractures), especially in predisposing conditions (advanced age, post-menopause, low mineral intake).

However, the evidence of causality is modest and not all research confirms it; dietary acid load should be considered as one of many factors that influence bone health.

From a practical point of view, promoting a diet rich in fruit, vegetables, alkalizing minerals, together with sufficient calcium and vitamin D intake, and physical activity, seems a reasonable strategy for the prevention of osteoporosis.

3.9 Kidney problems

The kidneys are responsible for removing acids from the blood and returning “bases” to the bloodstream. If acids are not removed from the blood, they move into the tissues. An acidifying lifestyle and diet strain the kidneys, sometimes to the point of blocking their optimal function, leading to kidney failure.

Dialysis may be necessary to purify the blood, but the most obvious and effective solution is to alkalize the blood and tissues by abandoning acidifying conditions and choosing healthier ones. Not only will you have a greater energy reserve of electrons for the body's countless internal and external activities, but kidney function will continue at normal healthy levels instead of deteriorating due to excess acid.

A diet with a high dietary acid load—i.e., rich in foods that generate acid residues after metabolism (e.g., animal proteins, refined grains, aged cheeses) and low in alkalizing foods (fruits, vegetables, tubers)—is associated with an increased risk of kidney damage and progression of chronic kidney disease.

The mechanisms involved include chronic stress from acid excretion by the kidneys, reduction of

bicarbonate, changes in the renal microenvironment, and lack of nutritional alkalizing support.

A high-acid diet requires the kidneys to eliminate more acids through H^+ ion excretion, ammonium (NH_4^+) production, and bicarbonate reabsorption. This continuous “overload” over time can damage the tubulo-renal structures, putting stress on the kidneys' buffering capacity (Scialla JJ, Anderson CA, 2013).

Mild metabolic acidosis can contribute to a reduction in serum bicarbonate, which is associated with worsening renal function. The study on stage 3-4 CKD confirms this (Angeloco LRN et al, 2020).

The acidic environment can affect the renal microenvironment and nephropathy, stimulating tissue damage factors, tubulo-interstitial fibrosis, and alterations in angiotensin/aldosterone/endothelin/etc., which promote the progression of kidney disease (Uchiyama-Tanaka, Y et al, 2025).

High-acid diets are often low in fruits and vegetables (which provide bases such as potassium and magnesium), elements that appear to protect renal function through an adequate intake of alkalizing elements (Banerjee, T. et al, 2014).

A 2019 meta-analysis highlighted that a high dietary acid load (DAL) is significantly associated with an increased risk of chronic kidney disease (CKD): the pooled odds ratio was approximately 1.31 (95% CI: 1.06-1.62) among subjects with high acid load compared to low acid load (Mofrad MD et al, 2019).

A prospective study conducted in a cohort with metabolic syndrome ($n \approx 5,874$) showed that participants in the upper third of PRAL/NEAP were more likely to have a $\geq 10\%$ decline in eGFR in one year than those in the lower third (OR 1.28 for PRAL) in diabetics/obese individuals (Valle-Hita C et al, 2022).

In patients with CKD (stage 3-4), one study reported that high PRAL was associated with lower serum bicarbonate values: each 1-unit increase in PRAL corresponded to a reduction of approximately 0.25 mmol/L of HCO_3^- (Angeloco LRN et al, 2020).

Another study of CKD patients (the ProgreDir Cohort Study) found that in diabetics, each 10 mEq/d increase in NEAP or PRAL was associated with an HR of approximately 1.27-1.31 for the onset of dialysis therapy (KRT) during follow-up.

3.10 Cancer

A diet with a high dietary acid load (i.e., rich in foods that generate metabolic acid residue after digestion/metabolism) is associated with an increased risk of developing certain types of cancer. The mechanisms involved include inflammation, metabolic stress, altered tissue microenvironment, and reduced intake of protective foods.

A high-acid diet can promote a state of mild or residual metabolic acidosis, which stimulates low-grade inflammatory processes. Chronic inflammation is a known promoter of carcinogenesis.

The elimination of excess acids requires increased metabolic and renal activity; this condition can alter the tissue microenvironment, generate oxidative damage, and promote mutagenesis.

High PRAL/NEAP diets tend to be low in fruits and vegetables (rich in bases, antioxidants, fiber) and higher in animal proteins, phosphates, and refined grains—characteristics that are already independently associated with an increased risk of cancer.

Although blood pH is maintained within very narrow values, local variations in acidic tissue (microenvironment) can promote the survival and proliferation of cancer cells or the progression of the tumor itself, due to an alteration in local pH and cellular homeostasis.

Some studies suggest that a slightly acidic environment at the cellular-tissue level facilitates malignant transformation, cancer cell migration, and metastasis. For example, the review “Dietary

acid load in health and disease” states that for a high DAL, the OR for rectal cancers was approximately 2.31 (CI 1.79-2.99) (Wieërs, M.L.A.J et al, 2024).

A 2022 meta-analysis showed that high dietary acid load scores (measured by Potential Renal Acid Load (PRAL) and Net Endogenous Acid Production (NEAP)) were associated with an increased risk of cancer: e.g., $RR \approx 1.77$ (95% CI 1.27-2.46) for high PRAL (Bahrami A et al, 2022).

Case-control studies on specific cancers (e.g., gastric, prostate, colon) found positive associations between high dietary acid load and increased risk. For example, for gastric cancer: $OR \approx 1.74$ (95% CI 1.132.66) for high PRAL (Ronco AL et al, 2022).

In breast cancer, a prospective study of 43,570 women found that the highest quartile of PRAL was associated with an HR of approximately 1.21 (95% CI 1.04-1.41) compared to the lowest quartile (Park YM et al, 2018).

Dietary acid load may be a marker of an overall less favourable diet (more meat, fewer vegetables) rather than an isolated causal factor.

The mechanism by which an acidifying diet influences carcinogenesis remains partly speculative and requires further clinical studies.

The effect may vary by tumor type, gender, age, and renal/metabolic health status.

Blood pH remains tightly regulated: it is not simply “acid in the blood” as a direct cause, but complex metabolic, tissue, and dietary effects.

Many studies have shown that what we eat influences our exposure to cancer.

Some foods defend us against the onset of cancerous cells, while others promote their development. Credit is given to the anti-cancer qualities of antioxidants found in beneficial foods such as vitamins C and E, beta-carotene, selenium, and the amino acid glutathione. These substances protect healthy tissues from acid damage that can trigger cancer. Foods that support a healthy body are alkaline; harmful foods are acidic.

To combat the onset of cancer, you need to increase the alkalinity of your tissues and therefore combine a diet based on green vegetables, fresh vegetable juice, unrefined salt, healthy oils, alkaline water, dietary supplements, physical activity, and alkaline lifestyle choices. Particular benefits can be derived from the use of alkaline mineral supplements (sodium, calcium, potassium, magnesium, cesium, and rubidium) and, even better, from the use of ionic mineral salts such as sodium, magnesium, potassium, and calcium bicarbonate, which alkalize instantly.

3.11 Neurodegenerative Diseases

Recent studies have explored the link between acidic pH and neurodegenerative diseases, such as Alzheimer's and Parkinson's. Inflammation and oxidative stress are key processes in the development of these diseases.

An acidic urinary pH may indicate an accumulation of toxins in the body, which could contribute to neuroinflammation. The relationship between inflammation and neuronal damage is well documented in the scientific literature, and an acidic urinary pH could act as an early indicator of this process (Sofic et al., 2005; Gannon et al., 2014).

Prolonged alterations in body pH and acid-base balance (systemic or intracellular) could be a contributing factor to neurodegeneration, not necessarily the sole cause but part of the pathological mosaic.

What has been highlighted is primarily the presence of lysosomal acidification dysfunction. One study has shown that in microglia, the failure of lysosomal acidification (i.e., too high/less acidic pH within the lysosomes) is implicated in the pathogenesis of neurodegenerative diseases, including

Alzheimer's and Parkinson's disease. (Lo et al., 2023). In particular, “Lysosomal acidification dysfunction in microglia: an emerging pathogenic mechanism of neuroinflammation and neurodegeneration” shows that alterations in lysosomal pH interfere with autophagy and the degradation of toxic protein deposits. (Quick et al., 2023).

There is also extracellular acidosis and inflammasome activation in neurons: in cultured cortical neurons, a lowered extracellular pH (e.g., pH 6.5 vs. ~7.4) activated the NLRP1 inflammasome, with increased caspase-1, IL-1 β , and IL-18. This suggests that extracellular acidosis may promote inflammatory processes in the brain. (Wang et al., 2015)

An acid-base imbalance in cerebrospinal fluid can also cause alterations in normal neurological functions: the study “Acid-Base Balance in Cerebrospinal Fluid” (JAMA Neurology) examined how systemic pH/CO₂/bicarbonate imbalances affect cerebrospinal fluid (CSF) pH and may correlate with neurological disorders (Posner et al., 1965). “Acid-base balance and cerebrovascular regulation” (2021) highlights that alterations in interstitial/CSF pH can affect cerebral blood flow, potentially relevant to the onset of neurodegeneration (Caldwell et al., 2012).

At the oral cavity level, although they do not directly measure pH, several studies suggest that saliva in patients with Alzheimer's disease or mild cognitive impairment shows alterations in biomarkers (β -amyloid, tau, lactoferrin, oxidative enzymes) that suggest metabolic dysfunction and potentially altered microenvironmental pH (Nijakowski et al., 2024).

Finally, an article in Johns Hopkins Medicine reports that in cellular models of Alzheimer's disease, pH disruption in endosomes (intracellular compartments) may contribute to the accumulation of β -amyloid, a key marker of the disease.

Dysfunctions in lysosomal acidification and intracellular compartments alter the internal pH of the cell, with consequences for protein degradation, the accumulation of toxic proteins (e.g., amyloid, tau), and brain inflammation: this is a potential contributor to neurodegenerative diseases. Systemic alterations in pH (or fluids such as CSF) can affect the brain through changes in blood flow, interstitial pH, and vascular functions.

Although direct measurement of salivary or urinary pH in relation to AD is not yet well validated, evidence shows that salivary biomarkers change significantly in patients, suggesting a possible involvement of the local acid-base environment.

Conversely, maintaining an alkaline urinary pH has been proposed as a way to reduce oxidative stress and inflammation, promoting better long-term health. An alkaline diet, which includes foods such as fruits and vegetables, has been associated with reduced production of inflammatory cytokines and better body weight control, both of which could decrease the risk of chronic degenerative diseases (Tucker et al., 2013).

4. FACTORS THAT CONTRIBUTE TO A HEALTHY BODY PH BALANCE

4.1 NUTRITION

4.1.1 Benefits of a vegetarian diet

Foods saturated with hydroxide ions, or electrons, are alkaline; those saturated with hydrogen ions, or protons, are acidic. Therefore, the pH scale is a valid indicator of the electrochemical energy of foods or beverages. Alkaline foods are full of electrons or electrochemical energy. It is the electrons that make them alkaline. Alkaline foods provide the body with energy in the form of electrons, i.e., electrochemical energy; acidic foods deprive it of electrochemical energy. Electrons or alkaline compounds are required to buffer, i.e., neutralize, the enzymes or acids in food.

Whatever acid or enzyme is contained in food, the body will release alkaline compounds or electrons to neutralize the acids in that food. The lower the acidity of the food, the lower the demand for alkaline buffers or electrons. The lower the demand, the more the body's alkaline reserves and energy will be preserved. Preserving all this potential then increases the body's overall energy. The body will be able to produce more alkaline buffers and allocate more electrons or electrochemical energy for use by organs and tissues, supporting metabolic functions and allowing repairs to damage caused by acidifying substances of environmental, dietary, and/or metabolic origin.

A vegetarian or vegan diet may be particularly suitable for supporting a better acid-base balance and preventing diseases related to a high dietary acid load. Firstly, there is a higher intake of alkalizing foods: vegetarian/vegan diets tend to include more fruits, vegetables, legumes, whole grains, and tubers, which are rich in potassium, magnesium, calcium, and citrates/malates linked to metabolic bases. These nutrients produce alkaline residues after metabolism, helping to neutralize acids. A review indicates that the high presence of potassium alkali salts is a key feature of plant-based diets that lower the DAL (Storz MA et al, 2022).

Vegetarian diets avoid or significantly reduce foods such as red meat, high-phosphorus dairy products, aged cheeses, and eggs in large quantities, which are foods with high PRAL/acid load. The NHANES study found that vegetarians had significantly lower protein and phosphorus intakes (Storz MA et al, 2022). A randomized trial showed that after only a few weeks, the vegan group had negative PRAL medians (i.e., net acid load < 0) while the meat-rich group was still positive. This suggests that transitioning to a plant-based diet rapidly lowers acid load (Müller, A et al, 2021).

A study based on data from the National Health and Nutrition Examination Survey (NHANES, USA) found that adults following a vegetarian diet had significantly lower dietary acid load (DAL) scores than omnivores: median PRAL approximately -0.44 mEq/d in vegetarians vs. $+11.90$ mEq/d in non-vegetarians (Storz MA, Ronco AL., 2022). A narrative review concluded that plant-based diets (vegetarian/vegan) are “the most effective in reducing dietary acid load” (DAL) through higher intake of potassium, magnesium, and other alkalizing salts, and lower intake of animal protein and bioavailable phosphorus (Storz MA et al, 2022). A randomized trial of overweight subjects showed that an isocaloric vegan diet for 4 weeks led to significant reductions in PRAL and NEAP compared to a meat-rich diet (Müller, A et al, 2021).

Since high dietary acid load values have been associated with an increased risk of various diseases (insulin resistance, diabetes, kidney disease, bone loss, inflammation), reducing this load through a plant-based diet can theoretically help prevent them. For example, Storz and Ronco state that for many chronic diseases in which metabolic acidosis is a contributing factor, including more plant-based foods can offer measurable benefits (Storz MA, Ronco AL., 2022). By reducing the acid load, the body's renal buffer systems are under less “stress,” helping to better preserve renal, bone, and metabolic function.

4.1.2 Alkalizing Foods

Vegetables are among the foods with the lowest calorie and sugar content and the highest nutritional value. They provide vitamins and minerals, fiber, electrons, phytonutrients, and alkaline salts.

Chlorophyll is what gives plants and vegetables their green color and plays a key role in photosynthesis. In other words, plants must be able to obtain the energy they need from sunlight. Just as haemoglobin in blood is composed of carbon, hydrogen, oxygen, and nitrogen organized around a single iron atom, chlorophyll is similar, except that the central atom is magnesium instead of iron (Breinholt, V et al, 1995).

Chlorophyll is a pigment found mainly in green plants, known for its antioxidant, anti-inflammatory, and detoxifying properties (Ferruzzi, M. G., Blakeslee, J., 2007; Hayes M, Ferruzzi MG., 2020). Studies indicate that chlorophyll intake can help improve gut health, modulate bacterial flora, and promote the elimination of toxins and heavy metals (Paran et al., 2019).

In addition, chlorophyll has shown potential effects in reducing oxidative damage at the cellular level and promoting DNA repair, supporting the prevention of certain chronic diseases (Khan et al., 2020). Some research also highlights a protective role against damage induced by carcinogens, suggesting a potential role in cancer prevention (De Rosa et al., 2009).

In the human body, chlorophyll helps blood cells distribute oxygen throughout the body.

It also reduces the binding of carcinogens to DNA in the liver and other organs, and destroys calcium stones, which the body creates to neutralize and eliminate excess acid (Chernomorsky, S.A et al, 1988).

Green vegetables, especially leafy greens, have the highest chlorophyll content. Vegetables are also an excellent source of alkaline salts, which protect against microbial proliferation and related mycotoxins, as well as helping to neutralize metabolic and dietary acids in the blood and tissues.

Vegetables, especially leafy greens, are incredibly rich in nutrients and provide virtually all the necessary vitamins, minerals, and micronutrients. The best dietary sources of chlorophyll are dark green leafy vegetables such as spinach, kale, Swiss chard, parsley, romaine lettuce, broccoli, and green algae (Manach et al., 2004). To maximize absorption, it is advisable to consume them fresh or minimally cooked.

By far the best source of chlorophyll is herbs.

Herbs are incredibly nutrient-dense, usually even more so than vegetables: wheatgrass and barley grass are particularly good sources of chlorophyll, and it is chlorophyll that gives herbs the energy to regenerate our bodies at the molecular, cellular, and emotional levels.

Wheatgrass contains more than 100 nutrients, including all known minerals and trace elements and every vitamin in the B complex family. It has one of the highest pro-vitamin A contents of any food and is rich in vitamins C, E, and K. Wheatgrass juice is 25% protein, a higher percentage than that found in meat, fish, eggs, dairy products, or beans. In addition, it contains high amounts of an antifungal and antitoxin substance called laetrile. Barley grass has a high content of an antifungal and antitoxin substance called laetrile. eggs, dairy products, or beans. In addition, it contains a high amount of an antifungal and antitoxin substance called laetrile.

Barley grass boasts four times more thiamine (vitamin B1) than whole wheat flour and 30 times more than milk. It also has more vitamin C than oranges (seven times more). Vegetables are also rich in antioxidants that protect cells throughout the body from oxidative damage, buffering dietary and metabolic acids and supporting lymphocytes or white blood cells, and releasing oxygen and hydroxide radicals. This action serves to neutralize acids while preserving the delicate pH balance of the body. Antioxidants are molecules that help maintain redox balance by neutralizing free radicals and protecting cell structures. They work through various mechanisms: electron donation, metal chelation, enzyme stimulation, and prevention of biomolecular damage. They play a protective role

in numerous diseases related to oxidative stress: cardiovascular, oncological, and neurodegenerative.

Research has demonstrated the protective effects of a wide range of antioxidants on an extensive array of symptoms and diseases; and these effects derive mainly from diets rich in antioxidants and not from supplements. The best way to get all the different types of antioxidants is to eat a variety of green vegetables (and non-sweet fruit) every day.

The article “Role of ROS and Nutritional Antioxidants in Human Diseases” emphasizes that a combination of antioxidant deficiency and malnutrition makes individuals more vulnerable to oxidative stress, which is associated with cancer, neurodegenerative disorders, and respiratory diseases (Liu Z, Ren et al, 1988).

The review “Revisiting carotenoids as dietary antioxidants for human health and disease prevention” explores the role of dietary carotenoids in antioxidant functions, indicating that a good dietary intake can help reduce oxidative tissue damage (Terao J, 2023). Vegetables are also rich in fiber, which is essential in reducing cancer and other serious health problems by significantly decreasing mycotoxicity. Fiber acts like a sponge, absorbing acids from the body. Insoluble fiber increases stool volume and promotes intestinal motility, preventing constipation (Anderson et al., 2009). Soluble fiber, such as that found in oats and legumes, forms viscous gels that slow the absorption of sugars and fats, helping to reduce blood sugar spikes and LDL cholesterol levels (Chutkan et al., 2012). Soluble fiber is fermented by intestinal bacteria, producing short-chain fatty acids (SCFAs) that nourish colon cells and have anti-inflammatory and immunomodulatory effects (Morrison & Preston, 2016).

A diet rich in fiber is associated with a reduced risk of cardiovascular disease, type 2 diabetes, obesity, and certain types of cancer, such as colorectal cancer (Reynolds et al., 2019).

4.1.2.1 Avocado

Avocado is an alkalizing, energizing, and hydrating propellant.

Avocados are a significant source of protein, monounsaturated fats, essential fatty acids, beneficial plant sterols, and chlorophyll. They are a source of a wide range of micronutrients and, moreover, contain no starch, very little sugar, and a high content of fats and proteins.

Avocados are considered the most easily digestible source of fats and proteins among all foods. In fact, they are 80% healthy fats and 15% protein. They provide more protein than cow's milk and contain all 18 essential amino acids. Avocados are also rich in healthy monounsaturated acids and essential fatty acids (7 varieties, including omega-3 and omega-6). Their healthy fats are useful in cell building, help lower cholesterol, and serve as an energy resource that can be burned by the body as fuel. They are a better alternative to the oxidation of glucose (sugar) or even protein. This quality makes them especially useful for diabetics, both type 1 and type 2. Foods containing unsaturated fatty acids and oleic acids (such as avocados) stimulate the production of a compound called OEA (oleoylethanolamide) which suppresses appetite. OEA is released into the small intestine where, through nerve endings, it communicates to the brain that the body does not need any more food. Other studies confirm that high levels of OEA aid in weight loss and reduce blood cholesterol and triglyceride levels.

Avocados also have high levels of beneficial phytosterols or plant sterols. Some sterols can help lower blood cholesterol levels, and some have been shown in animal studies to inhibit the development of tumors.

In addition, avocados contain a wide range of antioxidants and other nutrients, including vitamin A, B complex vitamins, folic acid, vitamins C, E, H, K, lutein, and even glutathione. Recently, it has been discovered that they contain almost twice the amount of vitamin E, making avocados the richest source of this vitamin among fruits. Vitamin E helps slow down the aging process, protects against

heart disease, and is a powerful buffer against metabolic and digestive acids. Lutein, a carotenoid that helps prevent certain types of cancer, particularly prostate and cervical cancer, and plays a key role in eye health, has also recently been discovered in avocados. Glutathione also helps prevent various cancerous conditions and heart disease by neutralizing food and metabolic acids, and avocados are an excellent source of these substances.

These fruits are also rich in alkaline buffer minerals that are important in neutralizing excessive acidity, including magnesium, copper, iron, calcium, and potassium, as well as trace elements. They contain a total of 14 minerals, each of which regulates an organic function and stimulates growth. Iron and copper help in the regeneration of red blood cells and in the prevention of nutritional anemia. In addition, they contain ionic sodium, which gives them a high alkaline reactivity without all the acidic sugar found in other fruits.

4.1.2.2 Tomatoes

Tomatoes are low in sugar, packed with antioxidants, and have a high water content. They are a great source of a very valuable nutrient: lycopene. Lycopene is a carotenoid found in many fruits and vegetables but most abundantly in tomatoes. Lycopene greatly helps to maintain the body's alkaline structure, so much so that there is evidence of its primary role in the prevention of cancerous conditions, especially of the prostate, breast, and cervix.

Tomatoes are most alkalizing when eaten raw. When cooked, they become slightly acidic and lose much of their vitamin C. However, cooking also destroys the cell walls of tomatoes, allowing the release of lycopene, whose availability in the body increases enormously. Olive oil helps the body absorb lycopene more easily. Therefore, tomatoes dressed with olive oil are an excellent combination. And if you cook tomatoes, try to do so in olive oil. Drying tomatoes (dehydration at low temperature) increases their nutritional value and lycopene content. Dehydration preserves all the electrochemical potential that is destroyed by cooking. Rehydration, starting from powder to obtain tomato sauce, maximizes the beneficial properties.

4.1.2.3 Sprouts

Full of vitamins, minerals, and complete proteins, sprouts are living plant food and are biogenic. Seeds become more alkaline when they sprout. During the germination process, plant hormones are activated; proteins are pre-digested and converted into simple amino acids that are easily assimilated and work better in the human body; fats are reduced to simple fatty acids that are more easily assimilated; and starches are converted into plant sugars that are more easily assimilated.

Sprouts, like soaked nuts and seeds, are an alkalizing, life-giving, revitalizing, and highly energizing food. They are high in electrochemical energy or electrons, pre-digested complete proteins, chelated minerals, nucleic acids, vitamins, RNA, DNA, and vitamin B12. Their plant phytochemicals are activated; their starches are broken down into easily assimilated plant sugars; their proteins are pre-digested into easily assimilated free amino acids; and their fats are reduced to soluble fatty acids. And as a result of sprouting, their nutritional content increases: biotin content increases by 50%, vitamin B5 increases by about 200%, vitamin B6 by 500%, folic acid by 600%, and riboflavin (B2) by 1,300%.

Suitable sprouts include common bean and alfalfa sprouts, mung bean sprouts, chickpea sprouts, green lentil sprouts, sesame sprouts, sunflower sprouts, buckwheat sprouts, hemp sprouts, and wheat sprouts. The best way to eat all legumes is as sprouts because, when sprouted, they are much easier to alkalize and do not produce acidic intestinal gas as they do when whole and cooked.

4.1.2.4 Lemon, lime, and grapefruit

Lemons, limes, and grapefruit (not sweet) are very beneficial. Although chemically acidic, when metabolized in the body, they have a virtually alkalizing effect, thanks to their high concentration of sodium bicarbonate and potassium salts.

They contain very little acidic sugar (lemons and limes 3%, non-sweet grapefruit 5%) and are rich in oxygen, thus preventing the proliferation of microorganisms and the increase of mycotoxins.

4.1.2.5 Pomegranates

Pomegranates are an alkalizing fruit with low sugar content, rich in vitamins C, E, and B6, and containing significant amounts of folic acid, vitamins B1, B2, and niacin. In terms of minerals, pomegranates are excellent sources of potassium, copper, and iron. They also contain other antioxidants, along with a high flavonoid content. Pomegranate seeds are rich in omega-5 CLA (conjugated linoleic acid) oils, which neutralize acids and have many other benefits.

Pomegranates promote optimal health because they are alkalizing, antioxidant, and anti-inflammatory. The juice and oils aid in the formation of healthy red blood cells. These characteristics and their particular nutrient content make them particularly beneficial for people with certain health problems, such as high blood pressure, heart disease, gout, obesity, and digestive problems such as diarrhea, cramps, and flatulence. Recent studies show a positive relationship between pomegranate consumption and reduced rates of prostate cancer and high blood pressure.

4.1.2.6 Herbs and spices

Herbs and spices provide both flavor and nutrients. Herbal teas can also be very beneficial. Freshness is, once again, essential: herbs and spices can become mouldy during processing (drying) and storage.

4.1.2.7 Vegetable juices

Although the fiber is lost, juicing increases all the other benefits of vegetables and herbs.

The body receives a higher concentration of quickly usable alkaline salts, vitamins, minerals, chlorophyll, and electrons from the extracts, which are easier and faster to assimilate.

Green vegetable juice is highly alkalizing.

4.1.2.8 Low-carbohydrate vegetables

Complex carbohydrates produce a large amount of acids when digested, therefore, they should not exceed 20% of the diet. Therefore, the vegetables to choose should be, above all, those with a low carbohydrate content, and legumes and cereals should be eaten in limited quantities because they are high in complex carbohydrates. Diets with 50% or more complex carbohydrates provide a favourable environment for the proliferation of microorganisms even in healthy digestive tracts. Simple carbohydrates from fruit, sugar, and white flour are even more conducive to microbial proliferation. Vegetables high in carbohydrates, including potatoes, winter squash (round zucchini, nutmeg squash, common squash), yams, and sweet potatoes, can be eaten in moderation.

New red potatoes are the best choice in the potato family because they are potatoes from the current year. Red potatoes are fresher than other potatoes but should still be consumed sparingly.

Most legumes such as cannellini beans, borlotti beans, azuki beans, black beans, white beans, chickpeas, split peas, cowpeas, and lima beans are primarily starchy. Two varieties are higher in protein and are therefore suitable for more frequent use: soybeans (especially edamame, the whole fresh bean) and lentils.

It is preferable to eat them fresh or dried, not from cans.

Grains should also be fresh, not preserved.

Grains form acids when digested, so consumption should be limited and only fresh, organic grains should be used. If sprouted, even better.

Wheat and rice are the most common complex carbohydrates that produce the most acid. These should not exceed 20% of your diet. However, if you have health problems or are tired, you should eliminate them altogether. Only a balanced and healthy body is able to handle them, but in small quantities.

Amaranth, quinoa, and spelt are only slightly acidic, while millet and buckwheat range from neutral to slightly acidic to slightly alkaline, and therefore do not contribute to the formation of excess intestinal mucus.

There are also other benefits to these grains. Buckwheat and millet grains are high in protein and digest slowly, keeping blood sugar levels balanced. Spelt contains more protein, healthy fats, and fiber than wheat. Spelt is also rich in mucopolysaccharides, which are vital complex sugars that literally hold the body together, lubricate the joints, and support immune function. It is also high in vitamin B17, which is an anti-cancer vitamin.

4.1.2.9 Soy

Soy is a source of protein and a wide variety of nutrients. Soybeans contain a number of beneficial chemicals:

1. Isoflavones: These are a type of phytoestrogen (plant estrogen) indicated in the prevention of hormone-dependent cancers such as many breast cancers.
2. Daidzein: A particular isoflavone that inhibits tumor growth. It also promotes cell differentiation in animals (while cancer cells are undifferentiated).
3. Genistein: a phytochemical that can inhibit tumor growth and promote cell differentiation. Studies have shown that it helps block the growth of prostate cancer and breast cancer cells.
4. Protease inhibitors (various phytochemicals): block the action of enzymes or acids that are possible promoters of tumor growth and counteract a wide range of tumors, including some of the most common: colon, breast, and liver.
5. Phytic acid: chelates mycotoxins that promote tumor growth, binding them and expelling them from the body. Studies have shown that it helps reduce the size and number of tumors in laboratory animals fed mycotoxins.
6. Saponins: Studies have shown a lower risk of certain cancers, including breast, prostate, stomach, and lung cancer, thanks to their effect. (Saponins are also found in chickpeas and ginseng).
7. Soy: helps prevent certain cancers, protects the heart, and balances the endocrine glands.

The best choice is fresh soy sprouts or a soy sprout supplement. Other good choices are soybeans, edamame, tofu, soybean oil, and non-GMO (genetically modified) lecithin (lecithin is a by-product of soybeans, found in liquid or granule form, to be used as an ingredient in recipes or sprinkled on salads and soups, or taken as a supplement). Soy milk, on the other hand, is not usually a good option because almost all commercially available varieties contain added rice syrup to sweeten it, and the syrup ferments and creates more acidity. Unsweetened soy milk is fine, organic is better, as always, and fresh is crucial.

Tofu is a very good source of protein and is certainly far better than animal foods and dairy products, as well as becoming an alkaline food when combined with calcium carbonate. One study identified tofu consumption as the only factor associated with a reduced risk of prostate cancer among Japanese men living in Hawaii. Another study found a strong correlation between soy food consumption and a

lower risk of breast cancer in Chinese women. Tofu is a good transitional food for switching to a vegetarian diet and, occasionally, as part of a balanced and healthy diet.

4.1.2.10 Oils

Fats play a crucial role in the body, and not consuming them at all leads to nutritional deficiencies and consequent degeneration. The solution lies in consuming healthy fats. About 20% of calories should come from healthy fats.

Long-chain polyunsaturated fats, found in fish, seeds, fruits, and vegetables, are alkaline and neutralize acids from diet and metabolic activity. In contrast, saturated fats, found mainly in animal proteins, are acidifying.

Essential polyunsaturated fatty acids (PUFAs), particularly omega-3s (e.g., eicosapentaenoic acid EPA and docosahexaenoic acid DHA) and omega-6s (e.g., linoleic acid LA and arachidonic acid AA), are critical to human health because they cannot be synthesized by the body and must therefore be obtained through diet (Simopoulos, 2002).

LCPUFAs are essential components of cell membranes, influence membrane fluidity and function, and are crucial in brain and visual development, especially in infants and children (Innis, 2007).

Omega-3s, particularly EPA and DHA, modulate eicosanoid production, reduce systemic inflammation, and improve cardiovascular function. Studies show that adequate omega-3 intake is associated with a reduced risk of cardiovascular disease, hypertension, and atherosclerosis (Calder, 2015).

LCPUFAs regulate the immune response and are involved in neuroprotection, helping to improve neurological disorders such as depression and cognitive decline (Bazinet & Laye, 2014).

A proper ratio of omega-6 to omega-3 is important for maintaining inflammatory balance; an excess of omega-6 can promote inflammatory states, while an increase in omega-3 promotes anti-inflammatory effects (Simopoulos, 2008).

What the body needs to obtain from good oils are essential fatty acids (EFAs). EFAs are therefore essential and indispensable for good health. They are the building blocks of the fats responsible for strengthening cell walls, including those in the blood. Polyunsaturated fats such as those found in flaxseed oil, borage oil, evening primrose oil, grape seed oil, and hemp oil help build cell membranes, produce hormones, and trap and eliminate acids.

Most oils contain both monounsaturated and polyunsaturated fats, and even those that are predominantly monounsaturated, such as olive oil (but also cold-pressed walnut oil and avocado oil), are beneficial. They are used for cellular energy, which means that when the body is in balance, it lives on them rather than on sugar. Fatty acids strengthen immune cells, lubricate joints, insulate the body against heat loss, provide energy, and are used to produce hormone-like prostaglandins, which protect against heart disease, stroke, high blood pressure, arteriosclerosis, and thrombosis. They are also necessary for energy metabolism and immune system health. AGEs can also help reduce arthritis, asthma, premenstrual syndrome, allergies, skin irritations, and certain behavioural disorders, as well as improve brain function.

Nuts, seeds, olives, avocados, and their respective oils are all good sources of healthy fats, including omega-3 and omega-6. The highest concentrations of AGEs are found in flaxseed oil, borage seed oil, and hemp seed oil.

4.1.2.11 Alkalizing Salt

Salt is essential for human nutrition and physiological processes. It is as important to our bodies as

water or air. We need all three to survive. Our bodies contain approximately half a pound of salt. Our blood, sweat, and tears all contain salt. So does our saliva. In fact, all bodily fluids are salty.

Pure salt is composed of the elements sodium and chloride. In addition to the function performed in the body by each individual element, sodium and chloride are used to form magnesium, potassium, and calcium. All five of these elements are mineral salts and represent the main form of electrolytes in the human body. These electrolytes perform a complex balancing act in the body to maintain hydration, blood pH, and nerve and muscle function at optimal levels. Alkalizing salts are compounds such as sodium bicarbonate (NaHCO_3), potassium citrate, potassium bicarbonate, or mineral water rich in bicarbonate/alkali ions which, when taken, can help increase the amount of bases in the body or reduce the acid load.

The idea is that these salts can help neutralize metabolic acids or “buffer” the acid load, supporting acid-base balance. Potassium citrate is used to prevent the formation of uric acid and calcium oxalate stones (Sakhaee K. et al., 2009). Supplementation with alkaline salts has been shown to improve glucose oxidation in muscles in a study of older adults, suggesting a possible positive effect on energy metabolism (Boschmann M et al, 2020).

Mineral salts also help normalize blood volume in the body and regulate blood pressure and intracellular fluid pressure. Mineral salts play an important role in keeping the heart beating properly and regulating metabolism. The body uses salt to produce iron, from which it forms hemoglobin in red blood cells. Calcium salts help build strong bones. Magnesium salts help balance body temperature. Sodium and potassium salts provide the correct water balance in and around cells, regulate the acid-alkaline balance in our blood, and are necessary for proper muscle function.

Salt is important in the digestion of food: the body uses salt to produce sodium bicarbonate.

Without enough salt, muscle cramps or weakness, dizziness, and exhaustion occur. And these are only the initial outward signs of something wrong inside the body. In extreme cases, this can eventually lead to convulsions and even death.

The salt concentration in the blood must be kept constant, and the body has various ways of ensuring that this remains the case. If you don't get enough salt, your body drastically reduces its elimination of salt (through urine and sweat) in an attempt to keep the salt concentration in your blood constant, and therefore increases the excretion of water. This leads to dehydration, possibly severe, with the risk of a medical emergency. The most commercially available salt is highly processed salt, which has been bleached and contains additives, preservatives, anti-caking agents, moisture absorbers, fluoride, and dextrose. However, it has been depleted of its natural mineral content.

Table salt is dried in huge dryers where the temperature reaches 650 °C and is chemically purified. The heating process is powerful enough to alter the natural chemical structure of the salt, as some of the elements are dispersed into the air in gaseous form. The resulting form of sodium is unable to meet the body's sodium chloride needs.

The ideal salt for the body would be that derived from healthy sea water and dried in the sun.

Unrefined, crushed, natural rock salt is intact and contains all its original minerals, so it should be alkalizing. The most important mineral salts for the body are: sodium bicarbonate, potassium, magnesium carbonate, and calcium. This combination of salts helps to ensure adequate levels of the four major electrolytes in our body. These salts are found naturally in all body fluids and help to reduce acidity in the lymphatic, circulatory, and digestive systems. The salts themselves have a pH of around 8.4.

Sodium bicarbonate can be used alone or in combination with other mineral salts for best results. It has a pH close to 8 and will turn litmus paper blue, indicating a pH higher than 8, even up to 10.

A randomized controlled study evaluated the effect of bicarbonate/potassium supplementation in elderly volunteers on a high-protein diet: supplementation with alkaline salts increased plasma

bicarbonate concentration, improved glucose oxidation in muscles, and increased serum magnesium concentration (Boschmann M et al, 2020).

Another study on mineral water rich in bicarbonate and sodium (HBS) vs. low-bicarbonate water showed that consumption of “alkalizing” water increased urinary pH and urinary bicarbonate, reduced urinary ammonium, and reduced net renal acid excretion after 28 days (Mansouri K et al, 2024). Another excellent choice is liquid colloidal mineral salts; these are salts suspended (evenly dispersed but not dissolved) in water. Colloidal salts are optimal because vital minerals (including calcium, potassium, and magnesium) and trace elements are so small that they are easily absorbed by cells. They do not need to be broken down at all. They are already in their bioavailable state, a quality that makes them vastly different from salt crystals or rock salt.

4.1.3 Alkaline Foods/Acidic Foods Ratio

To maintain a balanced pH in the blood and tissues, at least 70% of the diet should consist of alkaline foods and, therefore, no more than 30% of acidifying foods. And at least half of this 70% alkaline should be raw.

A diet with a high proportion of alkalizing foods (fruit, vegetables, legumes, tubers, whole grains) and a lower proportion of acidifying foods (red meat, aged cheeses, refined grains, processed foods) can be beneficial in reducing the metabolic acid load (less H^+ production from animal proteins/sulfides/phosphates) and makes the body's acid-base regulation less stressed. It ensures a greater intake of alkalizing minerals (potassium, magnesium, citrates) and dietary fiber, thus providing metabolic benefits, improved insulin sensitivity, and a better lipid profile.

Finally, it allows for a reduction in foods associated with metabolic risk (e.g., processed meat) and an increase in foods recognized as protective. Although blood pH does not vary significantly within the normal range in healthy individuals, acid load indicators (PRAL/NEAP, urinary pH) may reflect increased metabolic stress that could contribute to the onset of chronic diseases.

4.1.4 Eating habits

To keep your body more alkaline during the times of day when you are most active, you should follow the recommendations provided by Dr. Kousmine, which are to consume the most substantial and rich meal at breakfast (“eat like a king”), slightly reduce the amount for lunch (“eat like a prince”), and have a light dinner in the evening (“eat like a pauper”). This way, you have more nutrients available during the day and less acid to neutralize and eliminate while your body rests at night.

Raw foods contain electrochemical energy or vital force (technically, they are biogenic) that can be transferred, while cooked foods are deprived of the electrochemical potential of electrons because heat (above 47°C) destroys it. Cooked food forces the body to produce all the electrons (energy) it needs itself, causing unnecessary stress and taking resources away from other functions.

Sometimes, however, a little cooking or some other type of food preparation can actually be beneficial. Cooked carrots provide more vitamin A than raw carrots, for example, while raw carrots provide more fiber.

In general, however, the rawer vegetables you eat, the better.

Fresh food is essential, and organically grown food is preferable. Organic foods avoid exposure to pesticides and all the other chemicals that are routinely dumped on most products. They are usually more nutritious, partly because the soil (from which plants derive their nutrients) is less depleted than the soil on farms that use standard fertilizers. Organic products have a nutritional value 300 times higher than conventional ones.

Eating food as fresh as possible is also essential. The moment a vegetable is harvested, its nutrients

begin to break down.

4.1.5 Food Combinations

Food combinations are essential to ensure good nutrient assimilation and facilitate the digestive process.

They are based on knowledge of the digestion times of each food and the chemical reactions that one food can have with another along the digestive tract. Combining foods allows for better nutrient absorption: for example, vitamin C + non-heme iron improves iron absorption.

There is also potential synergy in antioxidant or protective capacities: an in vitro study shows that some combinations increase overall antioxidant capacity compared to the individual parts. Meals are more balanced and nutrients more complete: combining proteins, carbohydrates, fiber, and fats in a balanced way can help stabilize blood sugar, satiety, and energy (Cömert ED et al, 2022). There are a few rules to follow.

Vegetables (or fruit) with low sugar/high water content can be combined with anything. They should be eaten with proteins, starches, or cold-pressed oils and other vegetables.

It is okay to eat slightly acidifying starches with alkaline vegetables or low-sugar fruit, while it is preferable not to eat acidifying starches (including acidifying starchy vegetables) with animal proteins, acidifying fruit, or saturated oils.

For food combining purposes, sour taste does not necessarily correspond to acidifying foods. The two most important examples of this exception are lemons and tomatoes, which, despite their acidic taste, actually make the body more alkaline thanks to their high mineral salt content, namely sodium and potassium, which are more than enough to neutralize acidic sugars.

Thus, when choosing a cereal (including bread or pasta) or winter squash or potatoes, it should be accompanied by alkalizing vegetables and not acidifying fish, for example.

An in vitro study entitled “Effect of food combinations and their co-digestion on total antioxidant capacity under simulated gastrointestinal conditions” showed that certain food combinations affect antioxidant capacity after simulated digestion. Combinations of “fruit + whole grains/milk” show synergy, while “milk + fruit or tea” show antagonism (Cömert ED et al, 2022).

If you want to consume acidifying animal proteins, they should be combined with vegetables or low-sugar fruits, both of which are alkalizing. It is preferable not to eat acidifying animal proteins together with starchy foods or saturated oils. Alkalizing vegetable proteins can be combined with all vegetables and fruits, which are alkalizing (rich in electrons), low in sugar, and high in water content, as well as with healthy alkalizing mono- and polyunsaturated oils. When eating acidifying fish, it should be combined with alkalizing vegetables but not with acidifying grains.

Acidifying fruit with a high sugar content should be eaten alone to prevent excessive fermentation in the intestine. Fruit should not be combined with protein, starch, starchy vegetables (beets, potatoes, yams), or saturated oil. In practice, highly acidic fruit with a high sugar content (i.e., alkalizing fruit such as lemons, limes, grapefruit, raw tomatoes, avocados, red, yellow, green, and orange peppers) should not be consumed, except rarely and only in moderation and when in season. Combine healthy, alkalizing mono- and polyunsaturated oils with alkaline vegetables and alkalizing fruits (tomatoes, avocados, red, yellow, green, and orange peppers, lemons, and limes): these can also be combined with starches (which should make up 20% or less of the diet). Do not eat healthy and alkalizing mono- and polyunsaturated oils with animal fats (saturated) or acidifying proteins.

Seeds, nuts, and avocados, all excellent sources of healthy alkaline fats, can be combined with alkaline vegetable proteins or with acidifying animal proteins, acidifying starches, or even with high-sugar (acidifying) fruits. Acidifying starch and acidifying animal proteins are a bad combination.

Acids deplete sodium bicarbonate, which is a component of saliva necessary for proper alkalization of food. Acidifying starches such as potatoes, bread, pasta (and even whole grains) are converted into acidifying simple sugars in the body; therefore, eating very sugary fruit adds more sugar to the sugar already present (in essence: acid on acid). Oil slows down the digestion of starch; however, this is not a problem if acidifying starch does not exceed 20% of the meal, which should otherwise be alkalizing.

Mono- and polyunsaturated oils (hemp, flax, avocado, and olive) can neutralize acids and therefore should not be avoided as they are healthy. When acidifying animal proteins reach the stomach, it secretes more hydrochloric acid. When combined with acidifying starches, the sugars in the starches produce even more acid, causing indigestion, heartburn, and flatulence in addition to all the other negative effects of an overly acidic body. The same thing happens when more acid is added (including acids created by very sugary fruits). Oils slow down the alkalization of animal proteins, causing constipation and, ultimately, acid reflux, heartburn, and flatulence.

Fruit, or at least most fruit, is high in sugar and acidifying, so it is already problematic. Combining it with protein leads to overproduction of acid (as well as indigestion and flatulence).

Starch and fruit together, both acidifying, are equivalent to double the acidifying sugar. In addition, they have very different digestion times (acidifying fruit is digested extremely quickly), creating conditions for fermentation in the stomach and small intestine. Mixing acidifying fruit with saturated or trans oil can lead to constipation and poor nutrient absorption. Finally, while acidifying fruit acts in a degenerative way, vegetables are the alkalizing builders of stem cells, blood, and even red blood cells. Acidifying saturated oil slows down the digestion of acidifying animal proteins and acidifying starch (although the latter will only be a problem if starches exceed 20% of the diet).

The solution is therefore simple: combine no more than 4 foods from no more than 2 food categories at each meal. For example, prepare steamed broccoli, a tomato salad, mixed greens, and tofu or soba (buckwheat noodles) marinated in salt, but not both.

In summary: 3 vegetables and 1 protein food or 3 vegetables and 1 food with complex carbohydrates. Choosing fewer foods puts less strain on the digestive system. When you eat mainly foods that are rich in alkaline water, electrons, and low in acidic sugars, you no longer need to worry about the right combinations. It is impossible to combine them incorrectly, since problematic acidic foods that produce mucus are eliminated or limited. All foods that have a composition more similar to that of the human body (containing mainly water (70% or more), natural fats (20 to 30%), few proteins (5 to 7%), and very little sugar (0.5 to 3%)) can be combined with each other without any problem. It is preferable to consume drinks and food at different times. Do not combine an alkalizing meal with an acidifying drink. Do not drink something acidic with acidic food, otherwise you will cancel out the body's ability to neutralize acids. Cold acidifying drinks are particularly problematic because the cold blocks the release of sodium bicarbonate by the epithelial cells of the stomach. Drinking electron-rich alkaline water (or other alkaline liquids) in combination with acidifying foods helps to buffer acids and dilute the chemical components of acidic foods. Alternatively, if you want to eat acidic food, it is preferable to eat very juicy alkaline foods first, such as salads and alkaline vegetables, to better prepare yourself for the subsequent ingestion of heavier acidifying foods.

4.1.6 Foods to Avoid

4.1.6.1 Sugar

High sugar intake, especially in the form of added sugars or sugary drinks, is associated with an increased risk of obesity, type 2 diabetes, cardiovascular disease, high blood pressure, and mortality. Studies indicate that reducing added sugar intake is an important component of chronic disease prevention. Excess sugar, especially in the form of sugary drinks or foods high in added sugar, can contribute to increased calorie intake and thus weight gain, which is a risk factor for diabetes, CVD, and other diseases (Neelakantan N et al, 2021). Simple sugars rapidly stimulate an increase in blood

glucose and insulin secretion; over time, this can promote insulin resistance and progression to diabetes.

Excess sugar can promote the accumulation of hepatic triglycerides, non-alcoholic fatty liver disease (NAFLD), which in turn is associated with metabolic and cardiovascular damage. High sugar intake can alter plasma lipids (e.g., increased LDL cholesterol, triglycerides) as shown in the analysis cited.

Added sugars also contribute to low-grade chronic inflammation, which is a promoter of chronic diseases. All forms of sugar (white sugar, brown sugar, beet derivatives, cane sugar, corn sugar and syrup, maple syrup, honey, molasses, sucrose, fructose, maltose, lactose, glucose, mannitol, sorbitol, galactose, monosaccharides, date sugar, turbinado sugar, candy, sweet drinks, pastries, ice cream, chocolate, carob, and even natural fruit sugars), especially those that cause a rapid increase in blood sugar (cane sugar and corn sugar), should be consumed in extreme moderation. A meta-analysis of longitudinal studies found that the consumption of sugar-sweetened beverages (SSBs) is associated with an increased risk of type 2 diabetes, obesity, coronary heart disease, and stroke: for example, relative risk (RR) for diabetes ~ 1.20 (CI 1.13-1.28) for higher SSB consumption (Santos et al, 2022).

Another meta-analysis showed that each increase of 1 serving per day of SSBs is associated with an 8% increase in the risk of cardiovascular disease (CVD) and CVD mortality. (Yin J et al, 2021).

A recent systematic review indicated that high intake of total sugars and fructose was associated with an increase in all-cause mortality (RR ≈ 1.09) and cardiovascular disease mortality (RR ≈ 1.10), compared to minimal intake levels (Huang C et al, 2023).

A dose-response study showed that sugar intake is associated with an increased risk of hypertension: for approximately 250 g/day of sugars, the risk of hypertension increased (RR ~ 1.26 , CI 1.15-1.37) (Zhao Y et al, 2024).

A meta-analysis of the effects of free sugars on blood pressure and lipids showed that higher sugar levels were associated with an increase in triglycerides, total cholesterol, and LDL (Te Morenga LA et al, 2014).

4.1.6.2 Junk food

The term “junk food” (JF) refers to packaged snacks, sugary drinks, ready-made products, or fast food that is high in calories and low in nutritional value.

In the literature, they are often classified as ultra-processed foods (UPF) according to the NOVA food classification.

Studies show that high consumption of UPFs is associated with poorer diet quality, nutritional deficiencies, and an increased risk profile for numerous diseases.

JF is associated with excess calories and obesity: high energy density plus low fiber content leads to weight gain and obesity. Obesity is in turn a risk factor for diabetes, cardiovascular disease, and liver disease.

Its nutritional quality is extremely poor: these foods are high in added sugars, saturated or trans fats, salt, and additives, but low in fiber, vitamins, minerals, and protective phytonutrients. This creates a nutritional imbalance that promotes chronic inflammation and dysfunctional metabolism. Consuming JF establishes systemic inflammation and oxidative stress: a high intake of processed foods can increase inflammatory markers, reduce the functionality of the gut microbiota, and promote intestinal permeability (“leaky gut”), which contributes to chronic diseases. An umbrella review identified 45 meta-data analyses with nearly 9.9 million participants: greater exposure to UPFs was associated with an increased risk of 32 adverse outcomes (mortality, cancer, cardiovascular disease, mental disorders) (Lane MM et al, 2024). Metabolic dysfunction also occurs: insulin resistance, dyslipidemia, and fatty liver disease can be triggered by diets rich in junk food. A meta-analysis of liver diseases showed that

high UPF consumption was associated with an increased risk of non-alcoholic fatty liver disease (NAFLD) and liver fibrosis (OR $\approx$ 1.72 for NAFLD) in the 17 studies analyzed (Guo C et al, 2025).

In the long term, regular consumption of junk food leads to a negative metabolic load, compromising liver, cardiovascular, kidney, and mental health. A specific study on the psychological effects of junk food, a meta-analysis of adults, showed that high consumption of junk food was associated with a 16% increase in the likelihood of mental health problems (OR = 1.16; 95% CI: 1.07-1.24) (Ejtahed, HS et al, 2024).

Junk food, i.e., French fries, cookies, doughnuts, and anything else you can find in fast-food restaurants and elsewhere (etc., etc., etc.), should be avoided. But the list also includes many foods such as low-calorie ready meals and canned soup. All these foods are manipulated and processed from the outset, and any nutrients they may have initially contained are destroyed in the preparation process, even in so-called enriched products. What's more, they are loaded with sugar, processed or refined salt, artificial colors and flavors, additives, preservatives, and butter, margarine, or hydrogenated or partially hydrogenated (solidified) vegetable oil, and are deficient in fiber. They are, of course, all acidifying.

4.1.6.3 Dairy products

Like most animal foods, milk products contain acidic residues of hormones and pesticides, microorganisms, mycotoxins, and saturated fatty acids. All dairy products produce lactic acid.

In addition, intensively farmed dairy cows often eat preserved grains, i.e., grains treated with hormones and antibiotics, which are in turn derived from sugar and then concentrated in milk. Furthermore, cheese and yogurt are also fermented products.

Dairy products, among all foods, are the leading cause of intestinal mucus formation.

They are highly acidifying and can increase the risk of cancer, particularly prostate cancer.

A meta-analysis of 33 studies found that high intake of total dairy, milk, and cheese was associated with an increased risk of prostate cancer (e.g., RR $\approx$ 1.07 per 400 g/d of dairy) (Aune D et al, 2015).

Also in relation to the prostate, one study reported that high intake of whole milk was associated with a worse outcome in terms of progression/mortality (Song Y et al, 2013).

A mechanistic review showed that the milk/IGF-1 increase ratio is associated with an increased risk of prostate cancer (Harrison S et al, 2017). On the cardiovascular front, a meta-analysis of 55 studies found that total dairy consumption was associated with a modest reduced risk of hypertension, stroke, and cardiovascular disease (Chen Z et al, 2022).

Dairy products contain saturated fat, which in theory could negatively affect lipid profile and cardiovascular health. However, the evidence is conflicting, and many studies suggest neutral or even favorable effects (Soedamah-Muthu SS et al, 2018).

If the goal is prevention, attention should be paid to the quality of the dairy product (fat, type of processing, fermentation) and the overall dietary context. All milk derivatives should be greatly reduced in the diet. Alternatively, it is preferable to consume soy, almond, or hemp milk (avoiding the vast majority of those that are full of added sugar).

The most suitable animal milk is untreated milk from organically raised, pasture-fed goats. It contains caprylic acid, an antifungal agent. Milk is full of substances that humans do not need and, moreover, must either be converted for use (wasting our body's reserves for this process) or eliminated as toxins. No other animal species drinks milk after infancy, and certainly not milk from other species. It is important to remember that calcium intake in our bodies is not solely linked to milk consumption. All green leafy vegetables and herbs are inherently high in calcium (as well as iron, magnesium, vitamin C, and many of the B vitamins, but that's another story), as are celery, cauliflower, okra,

onions, green beans, avocados, black beans, chickpeas, tofu, almonds, hazelnuts, and sesame seeds.

It is also important to assess how much calcium you really need to keep your bones and body healthy. One of the things calcium does in the body is neutralize the acid created by the ingestion of animal proteins. When you consume these acidic foods, the body tries to return to its alkaline state in the only way it can: it takes calcium from the bones if there is none available in the food itself to do its job.

4.1.6.4 Refined Salt

It would be advisable to eliminate (or greatly reduce) table salt and be careful not to consume excess salt in processed foods: canned, bottled, packaged, frozen, jarred, restaurant, and junk foods, which, unless specifically labeled otherwise, are generally all loaded with salt. Excess salt (sodium) contributes to high blood pressure, which is one of the main risk factors for stroke, heart attack, and cardiovascular disease. In addition to its effect on blood pressure, salt can directly affect vascular function, oxidative stress, immune response, and the vascular tissue microenvironment.

Excess sodium can aggravate water retention, kidney overload (especially in the presence of kidney impairment), and promote progressive kidney damage.

Refined sodium chloride (table salt) is often present in many processed foods—so excess sodium can come not only from “added salt” but also from a diet rich in high-sodium industrial foods. A meta-analysis found that high salt (sodium) intake is associated with an increased risk of stroke: RR approximately 1.34 (95% CI 1.19-1.51) in groups with the highest intake compared to the lowest. (Li XY et al, 2012).

A recent review of the relationship between salt intake and cardiovascular disease (CVD) discusses the coexistence of multiple mechanisms: high blood pressure, direct vascular effects, interaction with microbiota, and genetic salt sensitivity (Han F et al, 2025). A systematic study showed that replacing common salt with a “salt substitute” (less sodium, more potassium) reduced systolic (-4.80 mmHg) and diastolic (-1.48 mmHg) blood pressure compared to normal salt (Tsai YC et al, 2022). A Mendelian randomization study suggested that higher salt intake is associated with an increased risk of dementia: OR $\approx$ 1.54 (95% CI 1.095-2.169) for genetic predisposition to higher salt intake (Shi, K et al, 2024).

4.1.6.5 Saturated fats

Saturated fats have numerous negative effects: clogged arteries, heart problems, cancer, and so on.

The culprits are hydrogenated or partially hydrogenated (saturated and solidified) fats in vegetable oil, margarine, butter, saturated fats, and almost all animal fats (from meat, poultry, eggs, and dairy products; only fish is an exception).

Food should not be cooked in fat or oil (it is better to steam it) or seasoned with these afterwards.

Good oils such as olive oil, flaxseed oil, and grapeseed oil should be used. Saturated fats tend to raise LDL cholesterol levels, and high LDL levels are a known risk factor for atherosclerosis and coronary heart disease.

Consuming high amounts of saturated fat may increase the risk of cardiovascular disease, especially if these calories are not replaced with unsaturated fats or if the diet is overall low in protective nutrients. Guidelines recommend moderating saturated fat intake and replacing it with unsaturated fats whenever possible. However, it is important to interpret the data in a broader context: not all studies show a strong association, and what also matters is the overall diet, lifestyle, and the quality of the fats consumed.

A 2020 systematic review with meta-analysis found that reducing saturated fat intake for at least 2 years was associated with a 17% reduction in the risk of combined cardiovascular events (heart attack, stroke) in long-term trials (Hooper L et al, 2020). The World Health Organization (WHO) states in an updated review that excessive intake of saturated fatty acids is a risk factor for noncommunicable diseases (NCDs) and recommends replacing some saturated fats with unsaturated fats (WHO, 2023).

4.1.6.6 Meat and eggs

Meat (pork, beef, lamb, chicken, turkey, etc.) and eggs are loaded with hormones, pesticides, steroids, antibiotics, microorganisms, mycotoxins, and saturated fats that promote heart disease, stroke, and cancer, among many other problems. Meat and eggs are highly acidic. Eating animal protein results in the appearance of uric, nitric, sulfuric, and phosphoric acids in the body.

Animals are fed preserved grains, which transfer all the associated problems to their meat.

There is a strong correlation between animal protein and various types of cancer, particularly breast, thyroid, prostate, pancreatic, endometrial, ovarian, stomach, and colon cancer. High meat consumption—especially processed meat—is associated with an increased risk of cardiovascular disease, cancer, diabetes, and overall mortality, according to many indexed evidence sources.

Red meat often contains high amounts of saturated fat and cholesterol, which can contribute to increased LDL cholesterol, atherosclerosis, and therefore increased cardiovascular risk. Red meat is rich in heme iron, which can catalyze the production of free radicals and thus promote oxidative damage, inflammation, and cellular mutagenesis. In the case of processed meat, additives such as nitrites/nitrates, high amounts of sodium, N-nitrosamines, polycyclic aromatic hydrocarbons (PAHs), or heterocyclic amines (HCAs) generated during high-temperature cooking are involved, all of which are linked to carcinogenic and cardiovascular risk. High red meat consumption may be associated with worsening insulin sensitivity and an increased risk of type 2 diabetes, which in turn is a strong risk factor for cardiovascular disease and other problems (Micha R et al, 2010).

Combined, these alterations may increase the risk of total mortality, as shown in the studies above, if consumption is high and consistent over time. A meta-analysis of prospective studies found that consumption of unprocessed red meat was associated with an increased risk of cardiovascular disease (CVD) with HR $\approx$ 1.11 (95% CI 1.05-1.16) per 100 g/d increase; for processed red meat, the association was stronger: HR $\approx$ 1.26 (95% CI 1.18-1.35) per 50 g/d increase (Shi W et al, 2013). A systematic review concluded that long-term consumption of increasing amounts of red meat and, in particular, processed meat is associated with an increased risk of total mortality, cardiovascular disease, cancer, and type 2 diabetes in both sexes (Battaglia Richi E et al, 2015). A specific meta-analysis on the association with cancer shows that high red meat consumption was significantly associated with a higher risk of various cancers: for example, colorectal, colon, rectal, lung, and liver (Micha R et al, 2010).

Anatomically and physiologically, humans are not designed to be carnivores or omnivores. The long and intricate human digestive tract is designed for the slow absorption of complex and stable plant foods. Carnivores have simple, short intestines to allow animal food to pass through as quickly as possible. Their intestinal microorganisms are also different from those of humans.

On the other hand, starch digestion in humans is quite elaborate, while carnivores eat little or no starch. If humans were carnivorous animals, we would have teeth and jaws designed to tear flesh. Only our tools allow us to ignore this obvious and natural limitation, not to mention that we do not obtain any nutrients from hides, feathers, entrails, and bones, which true carnivores do. Finally, we rarely eat raw meat. We almost always need to cook it to kill parasites and other harmful microorganisms: none of this is necessary for true carnivores. Humans are structured to be vegetarians. Moderating meat consumption, choosing lean cuts, limiting processed meat, and incorporating it into a healthy diet (rich in fruits, vegetables, whole grains, and legumes) can be a

prudent health strategy.

4.1.6.7 Refined grains

Refined grains, compared to whole grains, have lower fiber, mineral, and micronutrient content, which in turn affect glycemic regulation, satiety, and gut health. A comparative study between whole grains and refined grains found that the dietary fraction consisting of refined grains was associated with an increase in total mortality: for every 200 kcal/day increase from refined cereals, there was an estimated 3% increase in the risk of death (Yu, Dan et al, 2023). In addition, lower production of short-chain fatty acids (SCFAs) from intestinal fermentation in environments with low fiber intake deteriorates the health of the gut microbiota and potentially increases systemic inflammation (Yu, Dan et al, 2023).

High amounts of rapidly absorbed carbohydrates (such as those from refined grains) can contribute to blood sugar and insulin spikes, which over time promote insulin resistance, obesity, and metabolic diseases. Some case-control studies have found associations between high intake of refined grains and cancers of the upper aerodigestive tract (oral cavity, esophagus, and larynx), suggesting that grain quality and processing may have implications for carcinogenesis (Levi F et al, 2000).

A systematic meta-analysis (17 publications) found that high intake of refined grains was associated with an increased risk of colon and stomach cancer (Gaesser GA et al, 2020). Finally, an international prospective study of 137,130 participants (PURE Study cohort) found that consumption of ≥ 7 servings/day of refined grains was associated with a 27% increased risk of early mortality, 33% increased risk of cardiovascular disease, and 47% increased risk of stroke compared to consumption of < 50 g/d. (SFU, 2021).

4.1.6.8 Alcohol

Alcohol consumption, especially when high or habitual, is associated with numerous health risks: weight gain, abdominal obesity, liver disease, various types of cancer, cardiovascular disease, and increased mortality. The dose matters: the higher the consumption, the greater the risk—but even moderate consumption is not necessarily safe.

Alcohol has a direct toxic effect: ethanol and its metabolite acetaldehyde are toxic to cells, inducing oxidative stress, DNA damage, and liver alterations. It affects energy metabolism and body weight: alcohol provides “empty” calories that can increase total energy intake without adequate compensation, promoting weight gain (Kwok A et al, 2019). Alcohol is a causal factor in cancer of the liver, upper aerodigestive tract, colon-rectum, and breast; it also causes liver damage, pancreatitis, cardiovascular changes, and neurological dysfunction.

A systematic review of 5,953 articles, including 14 studies, concluded that chronic alcohol use increases the risk of numerous diseases: cancers of the oral cavity, esophagus, and liver; liver cirrhosis; hypertension; and pancreatitis (Levesque C et al, 2023). Furthermore, in a study with over 10 years of follow-up, increasing alcohol intake was associated with an increased cumulative combined risk of cardiovascular disease, cancer, and mortality: for example, HR for > 750 g/week of alcohol compared to 1-25 g/week was ~ 1.57 (95% CI 1.30-1.90) (Zhang, X et al, 2021)

While the harmful effect increases with increasing consumption, recent studies suggest that even ‘moderate’ consumption is not risk-free (Fillmore KM et al, 2006). An analysis of 107 prospective studies with approximately 4.8 million participants showed that there is no significant protection with low alcohol intake compared to not drinking and that the risk of all-cause mortality begins to increase even at relatively low daily levels (> 25 g/d for women, > 45 g/d for men) (Zhao J et al, 2023).

4.1.7 How to choose foods

The choice of foods to eat can be guided by knowledge of their acidification capacity.

There are commonly available lists that provide information on the pH of foods or other variables, such as PRAL.

4.1.7.1 Food pH

Vegetables and fruit with low sugar content

- Sorrel + 11.5
- Garlic + 13.2
- Asparagus + 1.1
- Avocado + 15.6
- Fresh red chard + 11.3
- Broccoli + 16.2
- Artichoke + 1.3
- Carrot + 9.5
- White cabbage + 3.1
- White cabbage + 3.3
- Red cabbage + 6.3
- Kohlrabi + 5.1
- December green cabbage + 4.0
- Savoy cabbage + 4.5
- Fresh cucumber + 31.5
- Onion + 3.0
- Comfrey + 1.5
- Watercress + 7.7
- Dandelion + 22.7
- Dog grass + 22.7
- Chives + 8.3
- Grass (wheat) + 21.4
- Wheat grass + 33.8
- Kamut grass + 27.6
- Barley grass + 28.7
- Shaving grass + 21.7
- Alfalfa + 29.3
- Green beans + 11.2
- Soybean sprouts + 29.5
- Fresh endive + 14.5
- Lettuce + 2.2
- Fresh capuchin lettuce + 14.1
- Lime + 8.2
- Lemon + 9.9
- Cayenne pepper + 18.8
- Dried peas + 0.5
- Fresh peas + 5.1
- Tomatoes + 13.6
- Leek (bulb) + 7.2
- Horseradish + 6.8
- White horseradish (spring) + 3.1
- Turnip + 8.0

- Turnip navone + 3.1
- Radish + 16.7
- Black summer radish + 39.4
- Celery + 13.3
- Sprouted chia seeds + 28.5
- Sprouted horseradish seeds + 28.4
- Mizuna + 4.8
- Spinach (other than March spinach) + 13.1
- March spinach + 8.0
- Rhubarb stalks + 6.3
- Zucchini + 5.7

Organic cereals and legumes

- White beans + 12.1
- Lima beans + 12.0
- Fresh soybeans + 12.0
- Soy flour + 2.5
- Spelt - 0.5
- Wheat - 10.1
- Pure soy lecithin + 38.0
- Lentils + 0.6
- Millet - 0.5
- Soy nuts (soybeans soaked and then air-dried) + 26.5
- White rice - 18.5
- Brown rice - 12.5
- Buckwheat seeds - 0.5
- Granulated soy (cooked and ground soy) + 12.8
- Tofu + 3.2

Nuts and Seeds

- Wheat germ - 11.4
- Almonds + 3.6
- Hazelnuts - 2.0
- Walnuts - 8.0
- Brazil nuts - 0.5
- Macadamia nuts - 3.2
- Hemp seeds + 7.6
- Cumin seeds + 1.1
- Cumin seeds + 2.3
- Fennel seeds + 1.3
- Sunflower seeds - 5.4
- Flax seeds - 1.3
- Sesame seeds + 0.5
- Pumpkin seeds - 5.6

Fats (fresh, cold-pressed oils)

- Boiled butter (Ghee) - 1.6
- Coconut milk - 1.5
- Olive oil + 1.0
- Borage oil + 3.2
- Hemp oil + 4.7

- Evening primrose oil + 4.1
- Sunflower oil - 6.7
- Pomegranate oil + 3.1
- Fish oil + 4.7
- Flaxseed oil + 3.5

Fruit

- Rosehip - 15.5
- Pineapple - 12.6
- Mandarin orange - 11.5
- Ripe banana - 10.1
- Pear - 9.9
- Peach - 9.7
- Apricot - 9.5
- Papaya - 9.4
- Orange - 9.2
- Mango - 8.7
- Mandarin - 8.5
- Redcurrant - 8.2
- Ripe gooseberry - 7.7
- Ripe grape - 7.6
- Red bilberry - 7.0
- Pomegranate - 7.0
- Blackcurrant - 6.1
- Strawberry - 5.4
- Bilberry - 5.3
- Raspberry - 5.1
- Yellow plum - 4.9
- Plum - 4.9
- Date - 4.7
- Sweet cherry - 3.6
- Cantaloupe melon - 2.5
- Fig juice powder - 2.4
- Grapefruit - 1.7
- Watermelon - 1.0
- Fresh coconut + 0.5
- Sour cherry + 3.5
- Unripe banana + 4.8

Meat, poultry, fish, and eggs

- Pork - 38.0
- Veal - 35.0
- Beef - 34.0
- Sea fish - 20.0
- Chicken - 18.0 to 22.0
- Eggs - 18.0 to 22.0
- Oysters - 5.0
- Liver - 3.0
- Offal - 3.0

Milk and dairy products

- Cheese mature -18.1
- Quark - 17.3
- Cream - 3.9
- Homogenized milk - 1.0
- Buttermilk + 1.3

Bread (cereals, baked goods)

- White bread - 10.0
- White flour cookies - 6.5
- Whole wheat bread - 6.5
- Cereal bread - 4.5
- Rye bread - 2.5

Dried fruit

- Pistachios - 16.6
- Peanuts - 12.8
- Macadamia nuts - 11.7
- Cashews - 9.3

Unhealthy fats

- Margarine - 7.6
- Corn oil - 6.5
- Butter - 3.9

Sweets

- Artificial sweeteners - 26.5
- White cane sugar - 17.6
- Beet sugar - 15.1
- Molasses - 14.6
- Barley malt - 9.8
- Raw cane sugar - 9.6
- Fructose - 9.5
- Semi-raw cane sugar - 9.5
- Lactose - 9.4
- Barley malt syrup - 9.3
- Brown rice syrup - 8.7
- Honey - 7.6

Condiments

- Vinegar - 39.4
- Soy sauce - 36.2
- Mustard - 19.2
- Mayonnaise - 12.5
- Ketchup - 12.4

Beverages

- Liqueur from -28.6 to -38.7
- Fruit juice sweetened with white sugar - 33.4
- Tea (black) - 27.1
- Beer - 26.8
- Coffee - 25.1
- Wine - 16.4

- Packaged natural fruit juice - 8.7
- Distilled water (neutral)
- Fresh coconut water + 9.04

4.1.7.2 Food PRAL

PRAL (Potential Renal Acid Load) is an index that estimates how much a food affects the acid load in the kidneys, i.e., the production of acids or bases in the body after metabolism. PRAL assesses the acidifying or alkalizing effect of a food after digestion, considering its protein, phosphorus, potassium, magnesium, and calcium content.

It is expressed in mEq/100 g of food. If the PRAL is positive, the food produces acids (acidifying), e.g., meat, aged cheeses, cereals.

Conversely, if the PRAL is negative, the food produces bases (alkalizing), such as fruit, vegetables, and potatoes. It is important to know this because a diet with a high acid load is associated with bone loss, an increased risk of kidney stones, and worsening kidney function (especially in frail individuals). It is used in studies of alkaline diets and the prevention of metabolic or inflammatory diseases. It helps to understand the impact of a food on the body's acid-base balance and can guide food choices with a view to prevention and well-being.

PRAL (Potential Renal Acid Load) is not measured directly as a biological parameter, but is calculated using a formula based on the chemical composition of foods. PRAL is calculated, not measured directly. It is used to estimate the acid/base effect of foods on the body, which is useful for assessing the quality of the diet in terms of acid-base balance.

The standard formula for calculating PRAL (mEq/100g food) is

$$\text{PRAL} = 0.49 \times \text{protein (g)} + 0.037 \times \text{phosphorus (mg)} - 0.021 \times \text{potassium (mg)} - 0.026 \times \text{magnesium (mg)} - 0.013 \times \text{calcium (mg)}$$

This formula estimates the net acid load that the kidneys must manage after digesting food, taking into account:

- a. Acidogenic elements: protein and phosphorus
- b. Alkalizing elements: potassium, magnesium, and calcium

PRAL is estimated based on nutrients, not measured in a laboratory on the human body. It may vary slightly depending on the source of nutritional data and is expressed in mEq (milliequivalents) of acid load per 100 g of food.

Vegetables

Vegetables generally have a negative PRAL, making them alkalizing foods that are beneficial for acid-base balance.

Values may vary slightly depending on the source and cooking method.

Negative value

- Spinach raw: -14.0
- Swiss chard: -11.0
- Zucchini: -4.6
- Carrots: -4.9
- Potatoes (boiled): -5.6
- Cauliflower: -4.0
- Cucumbers: -0.8
- Fresh tomatoes: -3.1

- Peppers: −1.4
- Lettuce: −2.5
- Broccoli: −1.2
- Fennel: −2.2
- Onion: −1.5
- Pumpkin: −1.9
- Eggplant: −3.4
- Asparagus: −0.4
- Beets: −5.4
- Broccoli: −1.2
- Cabbage: −1.0
- Brussels sprouts: −0.5
- Turnip greens: −1.4
- Chicory: −4.2
- Endive: −2.0
- Leeks: −3.3
- Radishes: −3.7
- Arugula: −3.6
- Celery: −5.2
- Jerusalem artichokes: −0.9
- Savoy cabbage: −1.8
- Green beans: −0.3

Positive value

- Sweet corn: +0.9
- Champignon mushrooms: +1.0
- Fresh peas: +0.6

Fruit

Negative Value

- Bananas: −5.5
- Apples: −2.2
- Pears: −2.0
- Peaches: −2.4
- Oranges: −2.9
- Mandarins: −2.8
- Pineapple: −2.7
- Strawberries: −2.2
- Cherries: −3.6
- Grapes: −1.7
- Melon: −3.1
- Watermelon: −1.9
- Kiwi: −2.6
- Mangoes: −3.7
- Papayas: −4.0
- Lemons: −2.5
- Apricots: −4.8
- Plums: −2.4

Nuts (generally acidifying, as proteins and phosphates increase the acid load)

- Walnuts: +5.6
- Almonds: +2.2
- Cashews: +6.0
- Pistachios: +4.5
- Hazelnuts: +1.0
- Peanuts: +8.3
- Pine nuts: +6.8

Dehydrated fruit (often alkalizing, as it is rich in potassium)

- Raisins: −21.0
- Dried figs: −18.0
- Dried dates: −6.5
- Dried prunes: −9.5
- Dried apricots: −14.5

Cereals

Cereals tend to be acidifying, especially if refined. Whole grain versions contain more minerals, so they often have a higher PRAL. Some pseudocereals (such as buckwheat and quinoa) have lower or neutral values.

- White bread: +3.5
- Whole wheat bread: +6.5
- White pasta (cooked): +1.3
- Whole grain pasta (cooked): +1.8
- White rice (cooked): +1.7
- Brown rice (cooked): +1.9
- Oat flakes: +10.4
- Corn (cooked): +1.2
- Polenta: +1.5
- Barley: +12.5
- Spelt: +7.4
- Buckwheat: +1.4
- Quinoa: +1.5
- Amaranth: +2.0
- Millet: +3.5

Meat

Meat has a high PRAL due to its high protein and phosphorus content, and the more processed the meat (e.g., cured meats), the more acidifying it is.

Red meat

- Beef: +12.5
- Veal: +9.5
- Lamb: +11.2
- Pork: +9.3

White meat

- Chicken: +8.7
- Turkey: +9.9
- Rabbit: +7.8

Processed meat

- Prosciutto crudo: +14.0

- Prosciutto cotto: +10.5
- Salami: +11.4
- Frankfurters: +11.0
- Bresaola: +13.3

Fish

All fish and seafood are acidifying (positive PRAL), mainly due to their high protein and phosphorus content. However, they are also rich in good fats (omega-3) and micronutrients, making them useful in a balanced diet.

Common fish

- Cod: +10.1
- Salmon: +7.5
- Tuna: +10.9
- Mackerel: +8.7
- Sea bream: +7.9
- Sea bass: +7.5
- Trout: +9.3

Seafood

- Shrimp: +8.0
- Mussels: +6.5
- Clams: +6.1
- Squid: +7.2
- Octopus: +7.0

Dairy products

Aged cheeses are among the most acidifying foods. Milk and yogurt have a low PRAL, but it is still positive. Only butter is slightly alkaline, as it contains few acids and proteins.

Milk

- Whole cow's milk: +0.7
- Semi-skimmed milk: +1.0
- Skimmed milk: +1.1
- Goat's milk: +1.0

Yogurt

- Whole yogurt: +1.5
- Low-fat yogurt: +1.7
- Greek yogurt: +3.0

Aged cheeses (very high PRAL)

- Parmigiano Reggiano: +34.2
- Grana Padano: +29.0
- Pecorino: +26.0
- Emmental: +19.0
- Gorgonzola: +18.0

Fresh cheeses (less acidifying)

- Ricotta: +8.0
- Mozzarella: +7.4
- Feta: +11.0

Other dairy products

- Butter: -0.5 (almost neutral due to low protein content)
- Cream: +0.5

Eggs

Eggs are acidifying, mainly due to their protein and sulfur content, particularly in the yolk.

- Whole egg: +8.2
- Egg white: +1.1
- Egg yolk: +13.4

Beverages

Water

The PRAL of water depends on the minerals dissolved in it (some waters are slightly alkalizing if rich in bicarbonates).

Still water: PRAL $\approx$ 0 (neutral)

Fruit juices

100% fruit juices are alkalizing, if not artificially sweetened.

- Orange juice: -2.9
- Lemon juice: -2.5
- Apple juice: -2.2

Sugary/carbonated drinks

Acidifying and often rich in phosphates and refined sugars.

- Cola-type drinks: +2.5 / +3.0
- Energy drinks: +2.0 / +4.0

Plant-based milk

Depends greatly on the composition: some are neutral or slightly alkaline

- Soy milk: +1.0
- Almond milk (unsweetened): -1.0
- Oat milk: +1.2

Stimulating/nerve-calming drinks

Herbal drinks without sugar or additives tend to be neutral or slightly alkaline.

- Coffee (unsweetened): +1.4 / +2.0
- Barley coffee: +0.5 / +1.0
- Chicory coffee: -0.8 / neutral
- Black tea: +1.0
- Green tea: +0.5 / neutral
- Yerba Mate: +1.0 (similar to tea)
- Herbal infusions (chamomile, mint, lemon balm, etc.): -0.5 / -1.5 (often alkalizing)

Alcoholic beverages

All alcoholic beverages are acidifying, with variations due to alcohol and sugar content.

- Red wine: +1.0
- White wine: +1.5
- Beer: +1.3 / +2.0

- Spirits (vodka, whiskey, rum...): +2.0 / +3.0
- Sweet liqueurs: +3.0 / +5.0

Sweets

Natural sweeteners and sugars

- White sugar (refined beet or cane): 0 neutral (no protein or minerals)
- Raw/semi-raw cane sugar: 0 / -0.1 similar to white sugar, but with traces of minerals
- Fructose: 0 neutral
- Glucose: 0
- Lactose: 0
- Honey: -0.3 slightly alkalizing
- Molasses: -0.5 / -1.5 alkalizing due to the presence of minerals (iron, calcium, magnesium)
- Barley malt: +0.5 / +1.0 slightly acidifying (contains traces of protein)
- Barley malt syrup: +1.0 / +1.5
- Brown rice syrup: -0.3 / neutral varies depending on processing

Artificial sweeteners

- Aspartame, Acesulfame K, Sucralose, etc.: 0 / neutral

4.2 HYDRATION

Adequate hydration is a key element in regulating the body's acid-base balance, as it supports kidney function, promotes acid excretion, and helps maintain urinary and (to a lesser extent) blood pH. Although it is not the only factor, together with a balanced diet rich in alkalizing foods and tailored to the individual, hydration can help to better manage the body's pH.

Adequate hydration promotes good urinary volume and adequate renal perfusion. The kidneys are key in regulating pH and excreting H^+ and ammonium (NH_4^+) ions. If urinary volume is low (e.g., due to dehydration), acid excretion may be compromised.

Adequate fluid intake helps dilute urine and promotes more effective elimination of acids and toxins, reducing the buffer “load” required by the body. Alkalizing or bicarbonate-rich waters demonstrate that water itself, beyond simple “hydration” can influence urinary and blood pH: this suggests that the combination of fluids and minerals plus optimal hydration supports acid-base homeostasis.

The study “Acid-base balance and hydration status following consumption of mineral-based alkaline bottled water” showed that in healthy young subjects, consumption of “alkalized” mineral water (high in bicarbonate) led to an increase in urinary pH and blood pH, as well as improved hydration (lower urinary osmolality, higher urinary volume) compared to the control group (Heil, D.P, 2010).

The review “Dietary influence on body fluid acid-base and volume balance: The deleterious ‘norm’ furthers and cloaks subclinical pathophysiology” published in *Nutrients* in 2018 highlights that the current modern diet - with excess animal protein, salt, insufficient water - leads to a net “retention” of acids and sodium, and that adequate hydration together with increased fruit/vegetable intake is essential to counteract this phenomenon (Qian, Q, 2018).

Another more recent review, "Hydration Meets Regulation: Insights into Bicarbonate Mineral Water and Acid –Base Balance" from 2024/2025 summarizes how water with a high bicarbonate content and proper hydration positively influence both net acid excretion (NAE) and urinary parameters related to pH (Mansouri K et al, 2025).

If you don't drink enough water, you gain weight: mild dehydration slows down your metabolism by 3%. In a study based on data from the 2009-2012 NHANES cohort in the United States, it was observed that adults with inadequate hydration (urinary osmolality ≥ 800 mOsm/kg) had a higher body mass index (BMI) and a higher probability of obesity (OR ≈ 1.59) than those who were adequately hydrated (Chang et al., 2016). If you don't drink enough water, your body will retain water: an acidic body pushes water into the tissues to try to neutralize the acids found there. Optimal hydration promotes tissue perfusion, extracellular volume, and optimal metabolic function, factors that can support better energy expenditure and promote lipolysis. A mini review suggests the hypothesis that increased hydration may promote weight loss through decreased food intake and increased lipolysis (although much of the data comes from animal studies) (Thornton SN, 2016).

Drinking water before or during a meal can increase feelings of fullness, reducing the likelihood of consuming excess calories. Some studies suggest that part of the appetite may be mistaken for thirst. Proper fluid intake can prevent compensatory water retention and maintain a good body composition (lean mass/fat mass ratio) that is conducive to weight control.

Ensuring proper hydration (drinking an adequate amount of water daily) also appears to be important in reducing the potential for acid accumulation in the body, as it improves renal excretion of acids, promotes buffering function, and can also introduce alkalizing elements if the water is rich in minerals. In summary, if you want to maintain a good acid-base balance, optimal hydration is an important addition to a balanced diet and healthy lifestyle.

A good intake of water increases urine production and facilitates the excretion of H^+ ions, ammonium (NH_4^+), titratable acids, and other acidic metabolites. When the body is dehydrated, excretion is

reduced, which can lead to increased acid load retention. Proper hydration supports the buffering function of the kidneys: the kidneys are key in regulating acid-base balance—bicarbonate reabsorption, H^+ secretion, NH_4^+ production. Good perfusion and filtration volume help these processes work better. If the water contains bicarbonate or other alkaline salts, hydration also becomes a way of introducing bases that help neutralize part of the acid load.

Drinking plenty of water allows for dilution of the acid content and improved flow: increased fluid intake reduces the concentration of urinary solutes and acidifiers, promoting an environment more conducive to acid elimination. A randomized controlled trial showed that in healthy subjects, consuming 1500-2000 mL/day of mineral water with a high bicarbonate content (and low PRAL) for 4 weeks led to a significant reduction in net acid excretion (NAE) in urine, an increase in urinary pH, and a slight increase in serum bicarbonate, compared to water with a low bicarbonate content (Wasserfurth P et al, 2019).

A recent narrative review ("Hydration Meets Regulation: Insights into Bicarbonate Mineral Water and Acid–Base Balance") emphasizes that sufficient hydration - particularly with fluids that contribute bases (e.g., bicarbonate) - can improve acid-base balance parameters: increased urinary pH, reduced acid excretion, and potential benefits for the kidneys and bones (Mansouri K et al, 2025).

In a study on alkalizing water (bottled water with high pH/minerals) in young adults, it was observed that regular consumption of such water increased both urinary and blood pH, improving hydration and acid-base balance compared to a control group (Heil DP., 2010).

Lack of water is also the leading cause of fatigue during the day.

A 2% decrease in body fluids can result in a significant decrease in physical performance.

Adequate hydration helps maintain tissue perfusion, cognitive function, electrolyte balance, and efficient energy release. When the body is slightly dehydrated (~1-2% loss of body mass or more), many people experience increased fatigue, decreased alertness, and worsening mood. A 3% loss of water causes a 10% loss of muscle strength and an 8% loss of speed, as well as reducing muscle endurance. When you lose 4% of your body water, you experience confusion and a decline of at least 30% in your ability to perform physical tasks. Losing another percentage point causes concentration problems, drowsiness, impatience, and migraines. A further 1% reduction in body fluid can cause the heart to race and loss of control of body temperature regulation. Reaching 7% can trigger a fainting spell.

The loss of body water leads to a reduction in plasma volume, an increase in osmolarity, and poorer tissue perfusion; this can reduce the supply of oxygen and nutrients to the muscles and brain, giving rise to a feeling of fatigue. One study showed that even mild dehydration ($\approx 1.59\%$ of body mass) in men caused a significant increase in feelings of fatigue/inertia both at rest and during light exercise (Ganio MS et al, 2011).

Dehydration alters the electrolyte balance (sodium, potassium, magnesium), which is essential for nerve transmission, muscle contraction, and energy metabolism. Studies indicate that dehydration impairs cognitive function, attention, alertness, and mood: when the brain perceives a state of water stress, this can be interpreted as fatigue (Ganio MS et al, 2011).

During physical activity or in hot environments, dehydration worsens the perceived rate of exertion and reduces endurance (Barley OR et al, 2018).

A narrative review analyzing hydration in the general population reports that insufficient hydration is associated with worsening mood, symptoms such as fatigue, headache, and reduced concentration (Liska D, et al, 2019).

Even in its earliest stages, dehydration can lead to confusion, short-term memory problems, difficulty with basic calculations and verbal expression, and difficulty concentrating. Dizziness, cold hands and feet, anxiety, irritability, depression, and cramps may also occur.

As for the resulting ailments, when dehydration becomes more severe, symptoms include gastroesophageal reflux, joint and back pain, migraines, fibromyalgia, constipation, colitis, and angina. Severe dehydration is linked to asthma, allergies, high blood pressure, and skin problems such as eczema, rashes, pimples, spots, and acne. If you lose 15-20% of your body fluids, there could be an imminent risk to your life. In fact, although you can go up to about 30 days without food, you cannot survive 72 hours without water.

Other symptoms that appear in cases of dehydration include:

- Intense thirst: this is often one of the first signs that the body uses to indicate the need for fluids.
- Dry mouth, dry tongue: Saliva production and oral moistening decrease.
- Decreased urination/darker, more concentrated urine: When fluid intake is insufficient, the kidneys conserve water and urine becomes more concentrated.
- Headache, difficulty concentrating, reduced attention: dehydration can affect cognitive function and mood (Armstrong LE et al, 2012).
- Dizziness or light headedness, especially when standing up quickly (orthostatic hypotension): reduced plasma volume can cause reduced cerebral blood flow.
- Skin that “tends to remain folded” (“skin tenting” or reduced skin turgor), sunken eyes, chapped lips: physical signs often visible in moderate forms.
- Increased heart rate, rapid breathing: when fluid is lost, the heart and lungs work harder to maintain perfusion.
- Reduced tear production in children, sunken fontanelle in newborns, irritability/drowsiness in young children: in very young individuals, the signs are different and more severe.

4.2.1 How to hydrate

Proper hydration keeps the pH in balance so that the body can be healthy. If cells do not receive the necessary buffer minerals, they will extract alkaline minerals from the bones, muscles, and elsewhere in the body, leaving these areas defenseless. For optimal health, pure, alkaline water, charged with electrons and with an ideal molecular structure, is required.

Alkaline water neutralizes the acidic waste accumulated because of diet and metabolism and, when consumed daily in conjunction with a good diet, gently removes acids from the body.

4.2.2 Water Characteristics

Water must be pure, free of microbiological contaminants, heavy metals, and hazardous chemicals (Drinking Water Quality Standards) (Tsaridou, C., & Karabelas, A. J., 2021).

It must be properly mineralized: the presence of calcium, magnesium, and bicarbonate can be beneficial for both hydration and acid-base balance (Mansouri K et al, 2024).

The pH must be moderate: overly acidic water should be avoided; some studies consider water with a pH close to or slightly above alkaline (e.g., pH level between 7 and 8.5, e.g., 7.8) to be favourable.

It must have conductivity and total dissolved solids (TDS): moderate values indicate the presence of minerals but without undesirable high salinity (Suh H, Kavouras SA, 2019).

It must have adequate organoleptic “acceptability”: taste, smell, and turbidity that encourage consumption. If the water is not pleasant, it is less likely that a good intake will be achieved. If you drink acidic water, the body is forced to draw alkaline substances from its reserves to neutralize it; as a result, these reserves will no longer be available for any other alkalizing action, which is a problem when the substance drawn is calcium, which is responsible for strengthening bones. On the other hand, when you drink alkaline water, it will help your body expel acids from your tissues.

4.2.3 When to drink

You should drink regularly throughout the day, rather than “drinking large amounts at once.”

You need to adjust your intake according to physical activity, hot/humid environment, physiological state (pregnancy, breastfeeding), the presence of pathologies (fever, vomiting, diarrhea), or following high sweat loss. The ratio “body weight/7 x 250 mL/day” can be used as a formula to determine the amount of water needed per day, in the absence of situations that require a higher water intake (excessive heat, heavy sweating, consumption of very salty foods, etc.).

In a study of healthy US adults, it was found that a total water intake (TWI) of approximately 3.57 L/day for men and 3.20 L/day for women was associated with a mean 24-hour urinary osmolality of approximately 482 and 346 mmol·kg⁻¹ respectively, values indicative of good hydration. In a Spanish study, “Water Intake and Balance” reported water consumption in mL/kg of body weight; for example, approximately 44.9 mL/kg in the observed range (Laja García AI et al, 2019).

In an Australian analysis, the median value for adults was approximately 35.5 mL/kg (IQR range 26.1-47.8 mL/kg) of total water per day (Mallett LJ, et al, 2021).

The formula can be interpreted as follows: if you divide your body weight (in kg) by 7, you get a number that, when multiplied by 250 mL, gives you a certain daily volume.

Example: if you weigh 70 kg → $70/7 = 10 \rightarrow 10 \times 250 \text{ mL} = 2.5 \text{ L}$ per day.

For an adult weighing 70 kg, 2.5 L corresponds to approximately 35.7 mL/kg ($2500 \text{ mL} / 70 \text{ kg} \approx 35.7 \text{ mL/kg}$), which is very close to the median value of the Australian analysis ($\sim 35.5 \text{ mL/kg}$) (Mallett LJ, et al, 2021).

Compared to the US study where men consumed $\sim 3.57 \text{ L}$, if we consider an average weight of $\sim 100 \text{ kg}$ (assumption), the value 2.5 L would be lower; but if the weight were $\sim 70 \text{ kg}$, 3.57 L would be $\sim 51 \text{ mL/kg}$, higher than the formula.

Therefore, the formula “body weight/7 × 250 mL” produces a value that is not very conservative compared to certain studies that suggest $\sim 35\text{-}45 \text{ mL/kg}$, and much depends on lifestyle, physical activity, climate, and diet.

The “35-45 mL/kg” ratio may therefore be another valid indicator for this calculation.

One study showed that mineral water with a high bicarbonate (and sodium) (1500-2000 mL/day for 28 days) improved urinary acid-base balance parameters: increased urinary pH, reduced net acid excretion (NAE), and reduced urinary ammonium (Mansouri K et al, 2024). Attention should also be paid to simple signs: urine color (ideally pale yellow), thirst, and regular urination.

If you sweat a lot (sports, heat, physical work), you need to replenish not only water but also lost electrolytes (sodium, potassium) to maintain water balance and avoid hyponatremia. Drinking an adequate amount of water before meals or away from mealtimes can be a good strategy for increasing feelings of fullness and potentially reducing calorie intake at mealtimes, improving hydration distribution throughout the day, preventing water from being concentrated only at mealtimes, reducing possible confusion between thirst and hunger, and supporting good metabolic health.

Drinking water before a meal can partially fill the stomach before calorie intake, contributing to a feeling of greater fullness and potentially lower food consumption during the meal. In a controlled study of non-obese young adults, consuming 568 mL of water immediately before a meal significantly reduced energy intake during the meal ($\approx 1967 \text{ kJ}$ with water vs. $\approx 2551 \text{ kJ}$ without) and increased feelings of fullness (Corney RA et al, 2016). Water ingested before a meal allows the gastrointestinal tract to “prepare” itself: it can improve perfusion, gastric function, and optimize digestion compared to drinking large amounts of liquids during a meal, which in some cases could dilute gastric juices or slow down digestion. If part of the water is consumed away from meals, this prevents the entire volume of liquid from being concentrated at mealtimes, which can help maintain adequate hydration

throughout the day, improving the distribution of hydration and therefore metabolic function, rather than overloading the stomach or affecting digestion during meals. In addition, drinking water before meals can help avoid confusion between thirst and hunger: in some cases, the feeling of “wanting to eat” may be partly caused by mild dehydration or thirst; drinking beforehand can reduce this effect. In a trial of adults with obesity, drinking 500 mL of water approximately 30 minutes before main meals (along with a low-calorie diet) led to greater weight loss (-1.3 kg more in 12 weeks than the control group) (Parretti HM et al, 2015).

In another trial on type 2 diabetics, drinking 1 L of water before meals was associated with reductions in BMI, waist circumference, fasting blood sugar, triglycerides, and LDL cholesterol compared to the group that did not drink water before meals (Sedaghat G et al, 2021).

4.2.4 pH of water in Italy

List of the main Italian low mineral content waters

Waters in the range between pH 7 and pH 8.5 are highlighted in ***bold italics***.

Abruzzo

- 1 ***Fonte Primavera 7.6***
- 2 ***Fonte Valle Reale (Pureland) 7.5***
- 3 ***Santa Croce 8.0***

Basilicata

- 4 Felicia 6.0
- 5 Gaudianello 6.1
- 6 ***Leggera 7.5***
- 7 Lilia 6.9
- 8 Sveva 6.2
- 9 Toka 6.3
- 10 Vivien 6.4

Calabria

- 11 ***Calabria 7.8***
- 12 ***Certosa 7.4***
- 13 ***Fabrizia 7.2***
- 14 Fontedoro 6.0
- 15 ***Fontenoce 7.8***
- 16 ***Futura 7.9***
- 17 ***Limpida 8.0***
- 18 Mangiatorella 6.6
- 19 Serricella 4.7
- 20 ***Sorgente dell' Amore 7.5***
- 21 ***Vita Sana 7.8***

Campania

- 22 Acetosella 7
- 23 ***Ferrarelle 7.2***
- 24 ***Fiordacqua 8.0***
- 25 ***Fonte Ofelia 7.6***
- 26 Lete 6.1
- 27 ***Prata 7.2***
- 28 Santagata 6.1

29 *Santo Stefano* 8.2

Emilia Romagna

- 30 *Cerelia* 7.3
- 31 *Col Fabrizia* 8.0
- 32 *Fonte Chiara* 7.9
- 33 *Fonte Lieta – Conad* 8.1
- 34 *Fonte Vela* 8.0
- 35 *Fonte Ventasso* 8.0
- 36 *Fonti San Fermo* 7.9
- 37 *Galvanina* 7.2
- 38 *Monte Cimone – COOP* 8.2

Friulia Venezia Giulia

- 39 *Dolomia* 8.3
- 40 *Goccia di Carnia* 8.3
- 41 *Paradiso* 7.7
- 42 *Pocenia* 8.1
- 43 *Pradis* 8.0

Lazio

- 44 *Acqua di Nepi* 5.7
- 45 *Claudia* 5.7
- 46 *Cottorella* 7.6
- 47 *Egeria* 5.8
- 48 *Fiuggi* 7.0

Liguria

- 49 *Alta Valle del Trebbia* 8.0
- 50 *Fonte Santa Vittoria* 5.2
- 51 *Santa Clara* 7.2

Lombardia

- 52 *Allegra* 7.7
- 53 *Balda* 8.3
- 54 *Bernina* 7.4
- 55 *Boario* 7.5
- 56 *Bracca* 8.0
- 57 *Bracca-nuova fonte* 7.7
- 58 *Coop-sorgente Grigna* 8.0
- 59 *Fonte Tavina* 7.7
- 60 *Frisia* 4.8
- 61 *Gaverina* 7.5
- 62 *Leonardo-primaluna alisea* 7.7
- 63 *Levissima* 7.8
- 64 *Luna* 7.9
- 65 *Maniva* 8.0
- 66 *Neve* 8.1
- 67 *Norda-Daggio* 7.4
- 68 *Pineta-Sorgente Sales* 8.2
- 69 *Pureland-Naturale/Primula* 7.6
- 70 *San Francesco* 8.2

- 71 San Pellegrino 5.2
- 72 *Santa Corina* 7.9
- 73 *Sant'Antonio* 7.9
- 74 *Stella Alpina* 8.6
- 75 *Vaia* 8.2
- 76 *Vitasnella* 7.8

Marche

- 77 *Casteldelci* 7.6
- 78 *Elisa* 7.7
- 79 *Frasassi* 7.6
- 80 *Gaia* 7.5
- 81 *Nerea* 8.0
- 82 *Tinnea* 7.8
- 83 *Valdimeti* 7.9

Molise

- 84 *Molisia* 7.7
- 85 *Seoinia* 7.7

Piemonte

- 86 *Alpe Guizza* 7.2
- 87 *Alpi Cozie* 7.5
- 88 *Alte Vette* 7.5
- 89 *Cime Bianche* 7.5
- 90 *Crodo Lisiel* 8.0
- 91 *Fonte delle Alpi* 7.1
- 92 *Fonte Gaudenziana* 8.8
- 93 Lauretana 6.4

4.2.5 How to choose water

Not all water is the same, and its mineral composition (particularly bicarbonate, sodium, calcium, and magnesium) and adequate intake can influence the effect of water on acid-base balance.

You should choose mineral water with a high bicarbonate content and negative PRAL.

A controlled study showed that daily consumption (1,500-2,000 mL/day) of mineral water with a high bicarbonate and sodium content ($\geq \sim 1,800$ mg/L HCO_3^- , negative PRAL) led to an increase in urinary pH and a reduction in net acid excretion (NAE) in healthy subjects (Wasserfurth P et al, 2019)

Another study on athletes found that drinking bicarbonate-rich water (≈ 1.5 -2 L/day) positively affected acid-base balance biomarkers compared to normal water (Chiron F et al, 2024).

A narrative review highlighted that mineral water with a high bicarbonate content and very negative PRAL values can be a useful strategy for improving acid-base balance and possibly supporting kidney and bone health (Mansouri K, et al, 2025).

4.2.6 Alternative to water: Organic Vegetable Mixed Juice (OVJ)

Daily intake of fresh vegetable extracts or juices can offer a variety of benefits, such as:

- supplementation of nutrients and bioactive compounds (vitamins, carotenoids, polyphenols)
- improvement of certain metabolic parameters (cholesterol, blood pressure)

- favorable modulation of the intestinal microbiota

All the benefits of vegetables (and herbs) can be intensified simply by extracting their juice. Nutrients are more concentrated and more quickly and easily available to the body. With juices, fiber is lost but nutrients or electrons are released. Chewing does the same thing but not as thoroughly as a juice extractor.

The body needs fiber, so not all vegetables should be consumed in this way. But when you drink vegetables, your body is receiving a higher concentration of alkaline mineral salts, vitamins, minerals, chlorophyll, and rapidly available electrons: therefore, vegetable juices are very alkalizing. They also have an important purifying effect on the intestines. The juices of vegetables that are usually cooked also provide an alkalizing aid to the digestive organs.

The best and most alkalizing juices are those extracted mainly from green vegetables and herbs. Initially, when your taste buds may not yet be accustomed to the milder sweet taste of green vegetables, you can add a few carrots, beets, or red, yellow, or orange peppers, or use winter squash and sweet potatoes, but sparingly. These vegetables are sweet because they have higher levels of acidity produced by sugar, so they should be used in moderation, making up 20% or less of the juice; this means that 80% must be composed of green vegetables. As your body becomes more alkaline, green juices will taste increasingly pleasant, so you can reduce the percentage of carrots and beets to 10% or less and increase the amount of vegetables.

All green vegetables are excellent for juicing (celery, cucumbers, broccoli, green peppers, zucchini, green beans, lettuce, cabbage, green beets, and all kinds of leafy vegetables). Tomatoes are also excellent for juicing.

Since everything is concentrated in juices, it is particularly important to use organic products that are as fresh as possible, well washed, and soaked in pure, alkaline water (20 drops of sodium bicarbonate and/or potassium solution per 4.5 litres).

Vegetables that are excessively waxed should be peeled to remove the organic resins that coat them, a preservation procedure used in the agri-food industry.

When vegetables are centrifuged, blended, and squeezed to extract their juice, microzymes secrete acidic waste, making the juice moderately acidic, even though it comes from alkaline vegetables. Therefore, fresh juices must be alkalized by diluting them with alkaline water in a ratio of 1:10 or 1:20 (1 part juice to 10-20 parts alkaline water).

Juice should be drunk immediately after preparation and should not be left to stand for more than 10-15 minutes.

The method by which a blender turns whole fruits, vegetables, and even grains into liquid or creamy compounds is a process that incorporates a lot of air into the food, preserving the fibers that absorb the enzymes or acids in the foods and liquids you ingest, but making the nutrients less accessible to your body. The creamy texture also discourages chewing and encourages fast eating, thus completely depriving the food of the complementary oral secretions necessary for proper and complete digestion.

Drinking vegetable extracts or juices can be useful in contexts where the intake of whole vegetables is insufficient, as it can increase the intake of key nutrients and bioactive compounds.

However, it should be noted that many juices lose fiber compared to whole vegetables, and dietary fiber is important for satiety, glycemic control, and intestinal health.

The greatest benefits are documented when juices are free of added sugars, contain mainly vegetables (less sugary fruit), and are part of an overall healthy diet.

A randomized, double-blind, controlled study evaluated the daily consumption of “organic vegetable mixed juice (OVJ)” in adults with borderline cholesterol levels. After 4 weeks, the OVJ group showed a significant reduction in total cholesterol, triglycerides, LDL cholesterol, an increase in the

antioxidant enzyme superoxide dismutase (SOD), and improvements in circulation biomarkers (e.g., blood viscosity) compared to the placebo group (Lee, Y.-H et al, 2024).

One study examined the effects of a 3-day fruit/vegetable juice diet in healthy adults: changes in the composition of the gut microbiota were observed—a decrease in Firmicutes and Proteobacteria, an increase in Bacteroidetes and Cyanobacteria—suggesting that the consumption of vegetable/fruit juices may have a modulating effect on the microbiota (Henning SM et al, 2017).

Benefits on blood pressure also emerge from a study that tested the use of commercial vegetable juice (0, 8, or 16 ounces per day) for 12 weeks to help achieve the recommended vegetable intake. It was found that the introduction of 1-2 cups (~240-480 mL) of juice effectively increased vegetable intake and, in pre-hypertensive subjects, led to a decrease in blood pressure (Shenoy SF et al, 2010).

Another review of 100% fruit and vegetable juices (including vegetables) highlighted that these products contain vitamins, minerals, and bioactive secondary compounds (polyphenols, carotenoids) that can positively influence various health indicators: blood pressure, vascular function, lipid profile, oxidative stress, cognitive function, and gut microbiota (Rossi I et al, 2024).

4.3 ALKALIZING NUTRITIONAL SUPPLEMENTS

Today's food does not have the nutritional value it once had and should have. It is grown with artificial fertilizers in depleted soil and sprayed with pesticides to the point of almost completely destroying its nutritional properties. It is harvested early and transported over long distances, and its nutritional value is further diminished during transport, storage, and long shelf life. Every minute that passes in the all-too-long interval between food production and reaching the kitchen results in the loss of nutrients and electrochemical potential.

Based on the literature, the supplements with the most evidence are those containing:

- Alkalizing minerals: potassium, magnesium, calcium, citrates, or bicarbonates
- Forms that are easily absorbed (e.g., citrates)
- Moderate doses and included in the context of an appropriate diet and lifestyle

A study of 25 adults administered a multimineral supplement (MMS) rich in alkalizing minerals and observed an increase in mean urinary pH (from ~5.94 to ~6.57) and a slight increase in blood pH after acute intake (König D et al, 2009).

Another trial in elderly people on a high-protein diet showed that alkalizing supplementation increased plasma bicarbonate and improved certain metabolic parameters (even though the diet alone did not significantly alter the acid-base balance) (Boschmann M et al, 2020).

4.3.1 Liquid or powdered chlorophyll

In cases of acidity, you can take 1 teaspoon of liquid chlorophyll or a powdered vegetable concentrate of green fruits, vegetables, and herbs per day.

The ingredients of this supplement are: wheatgrass, barley grass, and kamut grass (organic). They should be mixed with a variety of green vegetables such as broccoli, kale, and spinach.

A supplement made from organic sprouted wheat (wheatgrass) is another excellent source of concentrated chlorophyll.

Some in vitro studies indicate that chlorophyll-related compounds may reduce the expression of adhesion molecules and inflammatory markers in human endothelial cells (Lin KH et al, 2013).

A systematic review analyzed the available data on the use of chlorophyll in therapy, comparing safety and efficacy (Ulbricht C et al, 2014).

A recent study explored the use of chlorophyll in animal models (mice with type 1 diabetes), obtaining preliminary results on the regulation of hepatic metabolism and oxidative stress (Wunderlich ALM et al, 2019).

A 2025 review discussed the therapeutic potential of chlorophyll and its derivatives in the context of diabetes (Sartore G et al, 2025).

4.3.2 Omega 3 and 6 oils

Long-chain polyunsaturated omega-3 oils can chelate or repel environmental, dietary, and metabolic acids. Omega-3s and omega-6s are normally part of human cells and are particularly abundant in brain cells, nerve synapses, visual receptors, adrenal glands, and sex glands. They protect the heart, inhibit cancer cells, and provide a host of other health benefits.

Omega-3 oils protect the heart in several ways: they help disperse saturated fatty acids, thus preventing the formation of atheromatous plaques; they prevent platelets from becoming too

aggregative, reducing the likelihood of clots forming that can cause heart attacks or strokes; they reduce triglycerides by up to 65%; they lower cholesterol and low-density lipoproteins (LDL); they reduce very low-density lipoproteins (VLDL) by half. In addition, they convert VLDL to LDL, which is particularly useful in people with diabetes. High triglyceride levels, especially LDL and VLDL, are associated with heart disease: hypertension, arteriosclerosis, heart and kidney failure, stroke, and heart attack. What's more, our bodies derive prostaglandin PG3 from EPA (eicosapentaenoic acid). PG3 helps prevent strokes and heart attacks, lowers blood pressure (by blocking the production of prostaglandin PG2 contained in meat), and prevents pathological blood clotting in the lungs and blood vessels.

The eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) in omega-3s are antifungal, lowering the levels of repair proteins (a sign of mycotoxins in the blood) in the arteries. Repair proteins are also involved in the development of atherosclerosis, so reducing them has a double benefit.

Omega oils can help lower blood pressure, blood cholesterol, and the risk of stroke and heart attack, normalize fat metabolism in diabetes, and decrease the amount of insulin required by diabetics (Zou B et al, 2025).

They prevent liver damage caused by alcoholism, reduce withdrawal symptoms after stopping alcohol consumption, and help recover from hangovers.

They contribute to the production of a prostaglandin that helps some schizophrenia patients.

They cause weight loss by increasing the metabolic rate and fat burning.

They provide relief from premenstrual breast pain and premenstrual syndrome. Borage oil, together with vitamins and minerals, has been shown to improve the condition of almost 90% of patients (Lira LG et al, 2019).

They prevent dehydration and atrophy of the lacrimal and salivary glands (Si

The intake of omega-3 (and, in controlled amounts, omega-6) has documented clinical benefits: reduced inflammation, improved lipid profile, and potential effects on the intestinal microbiota (Zhang Y et al, 2024).

4.3.3 Sodium bicarbonate

Sodium bicarbonate intake provides valuable support for acid-base balance in special contexts. The benefits are acute and more evident in specific contexts (e.g., high-intensity exercise).

In prolonged or moderate endurance activities, the effect may be modest or absent (Grgic J et al, 2021). Typical dosages in studies are around 0.2-0.5 g/kg of body weight. These doses can cause gastrointestinal disturbances (e.g., nausea, diarrhea) if not well tolerated (Grgic, J et al, 2021).

Bicarbonate is not recommended as a “universal supplement” for everyone: intake without considering sodium/volume balance/renal conditions can generate risks (hypertension, water retention, electrolyte disturbances), especially in individuals with medical conditions (Witham, M.D et al, 2015).

In addition, it allows for improved high-intensity physical performance/acid buffering.

A meta-analysis found that acute supplementation with sodium bicarbonate improves muscle endurance (small and large muscle groups) with a standardized effect (SMD) of approximately 0.37 (95% CI 0.15-0.59) compared to placebo (Grgic J et al, 2020). The official position of the International Society of Sports Nutrition (ISSN) concludes that supplementation (dose between ~0.2–0.5 g/kg) improves performance in high-intensity activities lasting between ~30 s and 12 min in men and women (Grgic J et al, 2021).

A study of well-trained cyclists showed that bicarbonate intake improved a 4 km test in hot conditions, with increased buffering capacity and improved completion time (Gough LA et al, 2022).

Sodium bicarbonate intake can offer valid benefits in specific contexts—for example, improving performance in high-intensity physical activities or supporting acid-base balance in conditions of acidosis. However, it is not a panacea: it must be carefully evaluated, considered in the context of diet, health status, and physical activity, and does not replace the basis of a balanced diet and healthy lifestyle.

4.4 REGULAR PHYSICAL ACTIVITY

Physical activity plays an important role in managing the body's acid-base balance, even though it does not permanently alter blood pH, which remains strictly regulated between 7.35 and 7.45. However, it improves the body's ability to buffer acids, especially during intense exertion or conditions of metabolic stress.

Physical activity does not directly change the pH of the blood, but it strengthens the body's ability to manage acid-base fluctuations, improves metabolic resilience, and prevents conditions associated with chronic imbalance, such as loss of bone and muscle mass.

It increases buffering capacity: regular training improves the body's ability to manage the accumulation of H^+ ions (acids) produced during exercise, especially in the muscles.

It also reduces acidification from a sedentary lifestyle and diet: a sedentary lifestyle combined with an acidogenic diet can lead to a mild state of chronic latent acidosis. Regular exercise stimulates physiological mechanisms (ventilation, electrolyte balance, renal excretion) that promote rebalancing.

Finally, it accelerates post-exercise recovery: training improves the efficiency of removing lactate and H^+ ions, promoting a faster return to physiological pH after intense activity.

The preferred type of physical activity is moderate aerobic activity (brisk walking, light running, cycling, swimming): this promotes oxidative metabolism and reduces lactic acid production. It is excellent for maintaining acid-base balance in the long term.

A balanced approach combining toning and strengthening exercises (high intensity) followed by aerobic activities such as running or swimming (which increase heart rate) can also be effective in activating metabolism in a healthy way, provided that the overall intensity is managed correctly.

The preferred training is high-intensity interval training (HIIT) or anaerobic training (e.g., sprinting, weight training), as it generates transient acidosis (muscle pH drops) but stimulates the adaptation of buffer systems. It is useful if performed 1–2 times/week with adequate recovery. Moderate aerobic activity (e.g., brisk walking, steady running, moderate cycling) promotes good oxygenation, allows for fat utilization and relatively moderate acid production, thus allowing the body's “buffer resistance” to be trained without overloading the acid-base system.

High-intensity intervals (HIIT) or anaerobic efforts quickly generate acidosis (high production of lactate and H^+). This is useful as a stimulus but requires adequate recovery. Studies such as that by Lühker et al. (Lühker et al., 2017) show that higher intensity leads to significantly lower pH.

The recommended training modalities are 3–5 times per week, 30–60 minutes per session, and 60–75% of maximum heart rate for aerobic activity, with short (30 sec–3 min) high-intensity intervals alternating with active recovery for HIIT.

High-intensity exercise leads to an increase in the production of H^+ ions and lactate, generating transient metabolic acidosis (blood pH can drop from ~7.4 to ~7.2 or less) during and immediately after exercise (Baranauskas, M et al, 2020).

A study by Putman et al. (Putman et al., 2003) on healthy men showed that, after a short cycle ergometer in a 7-day submaximal training program, there was an attenuation of the increase in H^+ ions (i.e., less “acidity”) during exercise compared to pre-training (Putman et al., 2003).

Another study on female ultramarathon athletes showed that acid-base and electrolyte imbalances (reduction in extracellular bicarbonate, pH variations) affect performance and recovery (Ribas MR et al, 2025).

4.5 BREATHING EXERCISES

The article “Short-term regulation of acid-base homeostasis of body fluids” highlights that buffer systems, respiration, and renal excretion are essential for coping with acid loads and maintaining optimal pH (Clancy J, McVicar A, 2007).

The respiratory system is one of the fastest regulators of blood pH: changes in alveolar ventilation alter the partial pressure of carbon dioxide ($P_a\text{CO}_2$) and therefore the concentration of carbonic acid (H_2CO_3) in the blood (McNamara J, Worthley LI, 2001).

The review article “Acid–base balance: a review of normal physiology” (Shaw & Gregory, 2022) states that, after chemical buffers, the respiratory pathway is the one that intervenes within minutes to hours to compensate for pH variations. Increasing ventilation (e.g., breathing more deeply/frequently) causes more CO_2 to be exhaled, decreasing the concentration of carbonic acid and increasing the pH; conversely, slow/ineffective breathing causes CO_2 to accumulate, thus lowering the pH (Shaw I, Gregory K., 2022).

In a state of metabolic acidosis (e.g., accumulation of H^+ or non-volatile acids), breathing may increase in response (compensatory hyperventilation) to eliminate CO_2 and reduce acidity.

Therefore, effective breathing can help maintain acid-base balance by modulating CO_2 , one of the main components of the equation $\text{pH} = \log ([\text{HCO}_3^-]/(0.03 \times P_a\text{CO}_2))$.

4.5.1 Breathing Techniques

Considering physiology, and to promote a good pH- CO_2 balance, the following breathing techniques are recommended:

a) Diaphragmatic/deep breathing

Inhale slowly and deeply, expanding the abdomen rather than using only the chest.

Exhale in a controlled manner, allowing for good CO_2 expulsion.

The goal is to improve alveolar ventilation, reduce CO_2 residues, and promote better balance.

b) Moderate breathing during physical activity

When exercising aerobically, it is important to maintain adequate ventilation to avoid excessive accumulation of CO_2 and H^+ . This indirectly supports pH. It is not necessary to hyperventilate (this can cause respiratory alkalosis) but to breathe in a controlled and deep manner.

c) Pursed-Lip Breathing

Breathe in normally through your nose. Breathe out very slowly through pursed lips (as if you were going to whistle), taking twice as long as the inhalation (3 sec/6 sec; 4 sec/8 sec...).

This technique prolongs the exhalation phase, helping to expel more carbon dioxide and reduce the overall respiratory rate.

d) Temporary Increase in Respiratory Rate

Some intense breathwork practices involve cycles of controlled hyperventilation followed by apnea. This leads to temporary alkalization of the blood, as demonstrated by some studies. However, these practices should be performed with caution and are not recommended for everyone, especially those with medical conditions.

e) Avoid unnecessary chronic hyperventilation

Breathing too quickly for no reason (anxiety, stress) can eliminate too much CO_2 , causing an increase

in pH and leading to respiratory alkalosis. The goal is to maintain efficient but not excessive ventilation.

4.5.2 Benefits of proper breathing

The benefits of proper breathing are:

- Better CO₂ elimination, which facilitates the neutralization of volatile acids, reducing the load on the buffer balance.
- Improved tissue oxygenation, supported by optimal pH. The article by Shaw & Gregory highlights that even minor alterations in pH can affect muscle function and oxygenation (Shaw I, Gregory K., 2022).
- Support during exercise and recovery phases: efficient breathing improves the body's ability to manage temporary acidosis (e.g., from anaerobic activity) and accelerate pH stabilization.
- Reduction of the risk of hypercapnia (CO₂ accumulation) or hypocapnia (excessive elimination), both conditions that alter pH and can compromise biological function.

4.5.3 Effectiveness of Breathing Exercises in Stress Management

The effectiveness of breathing exercises in reducing stress levels is linked to a combination of physiological and psychological responses in the body.

The main mechanism is the direct influence on the autonomic nervous system (ANS). Slow, deep breathing stimulates the vagus nerve, a key nerve in the parasympathetic system. This stimulation triggers the “relaxation response,” which counterbalances the sympathetic activation induced by stress.

As for the ability of breathing to regulate heart rate and blood pressure, we know that, through a phenomenon called Respiratory Sinus Arrhythmia (RSA), slow breathing synchronizes the activity of the heart with that of the lungs. Inhaling slightly accelerates the heartbeat, and exhaling slows it down. When you lengthen your exhalation, you maximize this parasympathetic effect, leading to an overall reduction in heart rate and blood pressure, alleviating the physical strain of stress.

Chronic stress leads to elevated levels of cortisol, the stress hormone. Regular breathing practices have been shown to reduce cortisol levels in the blood. Lower cortisol levels translate into less anxiety and improved mood.

Shallow, rapid breathing, typical of stress and anxiety, can lead to hyperventilation and reduced efficient oxygenation of the brain. Deep diaphragmatic breathing ensures better exchange of oxygen and carbon dioxide, improving oxygen supply to the brain, which contributes to greater calm and mental clarity.

Finally, on a psychological level, consciously focusing on the breath acts as a mental anchor in the present moment. This act of *mindfulness* breaks the cycle of anxious thoughts or worries about the future or past, providing a mental break from perceived stress.

5. CONSEQUENCES OF PH ALTERATION IN CONDITIONS OF HYPERACIDITY IN THE ORAL CAVITY

A frequently acidic oral environment (pH lower than normal) has very concrete impacts on oral health: it predicts caries, erosion, periodontal deterioration, microbial alterations, and reduced remineralization capacity. Maintaining a more neutral or slightly alkaline saliva/plaque pH, together with good saliva flow, helps protect teeth and oral tissues.

The main consequences of low oral pH are:

1. Enamel demineralization and increased risk of caries

Dental enamel consists of approximately 96% inorganic material (hydroxyapatite crystals, $\text{Ca}_{10}(\text{PO}_4)_6(\text{OH})$).

When the pH of plaque fluid or saliva falls below a critical value (approximately pH 5.5 for enamel), calcium and phosphate ions begin to dissolve from the crystals.

At higher pH (close to neutral), saliva is supersaturated with calcium and phosphate, promoting remineralization; but at low pH, saliva and plaque become unsaturated with hydroxyapatite and there is a net loss of minerals (Hemalatha, P. 1 et al, 2020).

When the pH is frequently below ≈ 5.5 in plaque or saliva, the enamel becomes unstable and hydroxyapatite dissolution begins because saliva is no longer supersaturated with calcium and phosphates, and local buffering activity is insufficient (Szkaradkiewicz-Karpinska AK et al, 2024).

The acidification process favors acidogenic bacteria (such as *Lactobacillus*) that produce acids from fermentable carbohydrates, further lowering the pH (Badet MC et al, 2001). A study that analyzed the microbiota of dentin tissue based on pH showed that acidic pH environments favour the predominance of cariogenic bacteria such as *Lactobacillus*, *Prevotella*, and others, suggesting that a low pH in plaque/dentin modifies the bacterial composition towards a more aggressive profile (Kianoush N, et al, 2014).

Research on children shows that a lower plaque pH is predictive of caries recurrence (Kalhan TA et al, 2017).

Another study on children measuring plaque pH after rinsing with sugar solutions showed that a lower minimum plaque pH (after stimulation) was significantly correlated with a higher incidence of caries in the following 4 years (Shimizu K et al, 2001).

One of the first recognizable clinical signs is white spot lesions: an area of the tooth appears shiny-opaque or lighter in color than the rest of the enamel, typically on the buccal surface or in the grooves of the molars. This occurs because the crystalline structure has lost minerals and become more porous, which diffuses light differently. At this stage, the surface is still intact (no cavities) but is vulnerable to progression.

Due to mineral loss, the enamel is thinner or has micro-porosity, which allows thermal, chemical, or tactile stimuli to be transmitted more easily to the dentin or the enamel-dentin junction, causing increased tooth sensitivity.

There is also an increase in surface roughness and loss of microhardness: in vitro studies have measured that exposure to acids leads to an increase in surface roughness (Ra), a decrease in enamel microhardness, and lesion depth (Larnani S et al, 2024).

For example, in one study, immersion in acidic solutions for 30 minutes showed significant alterations in microhardness (Kolumban, A. et al, 2021).

When the pH in the oral environment falls below the “critical” value (approximately 5.5 for enamel), the process of enamel demineralization is activated: mineral loss, the formation of opaque areas

(white spots), reduced hardness, surface roughness, and, if left untreated, progression to cavitation begin. Early recognition of these signs is important to intervene (e.g., with remineralization, improved hygiene, reduction of acid factors).

The progression of a demineralization process leads to cavitation and compromise of the tooth structure.

If the balance remains in favor of demineralization (frequent acids, low pH, poor salivary buffering capacity), mineral loss can extend to the dentin and lead to the formation of visible cavities. Furthermore, if the enamel is already compromised, chemical erosion (from food or gastric acids) can accelerate the damage.

Demineralization is followed by dental erosion.

Dental erosion is defined as the irreversible loss of hard tooth tissue (enamel $\pm$ dentin) caused by a chemical acid attack, not of bacterial origin (Ruiz, D. C. et al, 2023).

According to a systematic review, a frequently acidic oral environment (low pH, low salivary flow) promotes erosion: saliva normally neutralizes acids and provides minerals for remineralization; if these defenses are compromised, erosion increases (Dipalma G et al, 2023).

A clinical study evaluated changes in the enamel surface after drinking an acidic beverage: within 24 hours, visible morphological alterations (SEM) were noted on the enamel surface compared to baseline (Seong J et al, 2015).

In children/adolescents (in a systematic study), it was observed that erosions range from “removal of surface features” to “extensive tissue loss with possible pulp exposure” (Linnett V, Seow WK, 2001).

A loss of enamel luster can be observed: the enamel appears more opaque or “blanched” due to the loss of microstructure.

Concave areas, “cupping,” may appear on the surface of molars or premolars: the acid dissolves the surface, creating small “domes” or depressions (Ruiz, D. C. et al, 2023).

There is an expansion of yellow or dark areas: when the enamel is substantially thinned or lost, the underlying dentin (more yellow) appears visible as a color change.

In an acidic environment, tooth sensitivity increases: exposure of thin enamel or dentin causes heat, cold, and sweet-sour foods to cause pain or discomfort (Linnett V, Seow WK, 2001).

Finally, increased wear can be observed on the incisal edges and palatal/lingual surfaces, especially in individuals with reflux, athletes, and frequent drinkers of acidic beverages (Wilder-Smith, C.H. Et al, 2017).

2. Dental erosion

Prolonged exposure to an acidic environment (e.g., gastroesophageal reflux) leads to erosion of the hard tissues of the tooth (enamel, dentin) because the acidic pH directly corrodes the surface (Filipi K et al, 2011). Reduced salivary buffering capacity or reduced salivary flow exacerbate this effect.

In individuals with gastroesophageal reflux, increased oral acidity (due to gastric acid reflux) has been linked to dental erosion and worsened oral health (lower salivary flow, lower buffering capacity) (Filipi K et al, 2011).

3. Alteration of the bacterial flora of plaque and saliva

Acidic environments favor the selection of aciduric bacteria, which thrive better at low pH, and decrease “beneficial” alkalizing bacteria (e.g., ammonia generation from arginine) (Lorenzini, E.C et al, 2022).

This microbiological shift promotes a negative loop: more acidity, more acidogenic bacteria, more

acid production.

There is a selection for aciduric or acidogenic bacteria: bacteria that produce acids from fermentable carbohydrates (e.g., *Streptococcus mutans*, *Lactobacillus* spp.) thrive better in acidic environments (Inchingolo, A.D. et al., 2022). Conversely, bacteria that prefer a more neutral/alkaline pH or that generate bases (e.g., through arginine/urea) are less favored in an acidic environment (Szkaradkiewicz-Karpinska AK, 2024).

Persistent acidic pH leads to a reduction in diversity or a change in microbial composition: microbial communities become more “specialized” towards acidophilic species, with a potential increase in the “fitness” of these species compared to others (Inchingolo, A.D et al, 2022).

This change can lead to a more stable biofilm that is more resistant to low pH and more effective in producing acids, promoting carious lesions or other oral diseases.

Acidogenic bacteria produce lactate, organic acids, and CO₂, which further lower the pH and create a self-reinforcing cycle: the acidic environment promotes the development of more aciduric bacteria, which cause more acids to be produced (Inchingolo, A.D et al, 2022). The buffering capacity of saliva and alkalizing bacteria (which release ammonia from arginine/urea) is reduced or overwhelmed at this point (Szkaradkiewicz-Karpinska AK, 2024).

The biofilm with high acidogenicity and aciduricity is altered and there is a greater potential for enamel demineralization, reducing the local pH more often and for longer periods. In a study of plaque and salivary sediment, it was observed that adults with active caries had significantly higher acidogenic and aciduric potential (ability to produce and tolerate acid) in their biofilm than adults without caries (Georgios A et al, 2015).

Modulation of the oral microbiota is also reflected in clinical parameters: for example, in patients with root caries, a different microbial composition was observed compared to healthy subjects (Zhang RR et al, 2025).

Managing oral pH (e.g., reducing the frequency of fermentable sugar intake, ensuring good salivation, using buffering measures) has an effect not only on mechanical damage to the enamel but also on the microbial composition of the biofilm.

Interventions that promote a less acidic (more neutral or alkaline) environment can help shift the “set point” of the bacterial flora towards less cariogenic profiles. In a study on controlled nutrition, it was found that consuming hard cheese (which promotes the production of ammonia from arginine) increased the pH of the biofilm and modified the bacterial composition towards less cariogenic (more alkalizing) profiles compared to the usual acidic environment (Lorenzini, E.C et al, 2022).

4. Progression of periodontal disease

A lower salivary pH has been correlated with greater severity of periodontitis, greater attachment loss, and greater probing depth (Baliga S et al, 2013).

The acidic environment can compromise the local immune response and tissue regeneration capacity.

A study of adults with periodontal disease found that saliva pH was significantly lower in subjects with severe forms of periodontitis (≈ 6.25) than in healthier subjects (Lăzureanu PC, et al 2021).

In the presence of a more acidic oral environment (salivary or crevicular pH frequently lower than normal), periodontitis can progress more rapidly or more severely for various reasons:

- *Reduced salivary buffering capacity:* a lower pH often reflects reduced salivary flow or a lower capacity of saliva to neutralize acids. This means that the periodontal environment becomes more favorable for the growth of anaerobic and pathogenic bacteria (Lăzureanu PC et al, 2021).

- *Promotes colonization of periodontal pathogens:* Bacteria such as *Porphyromonas gingivalis*, *Fusobacterium nucleatum*, and other anaerobes thrive in more acidic environments, altering the biofilm and activating inflammatory and proteolytic processes that damage the gums and alveolar bone (Koppolu, P. et al, 2022).
- *Increased inflammation and tissue destruction:* The acidic environment can stimulate the production of oxidants and inflammatory mediators that accelerate bone resorption and clinical attachment loss (CAL). For example, high levels of oxidative stress and altered metabolites have been observed in the most severe cases (Rashid MH et al, 2024).
- *Worsening of clinical parameters:* deeper periodontal pockets, increased bleeding on probing (BOP), and more significant bone loss are observed at lower salivary pH conditions. This is demonstrated by the study on saliva pH related to periodontal severity (Lăzureanu PC et al, 2021).

Signs that may indicate that periodontitis is progressing in an acid-favorable environment include:

- Increase in periodontal pocket depth (probing depth)
- Increased bleeding on probing (BOP)
- Increased clinical attachment loss (CAL) and alveolar bone loss visible on radiographs
- Lower salivary pH, lower salivary flow
- More plaque and tartar accumulation
- Receded gums, root exposure, sensitivity
- Changes in periodontal microbiota towards more pathogenic profiles

5. *Reduced remineralization capacity*

In conditions of chronic acidity, saliva is less supersaturated with calcium/phosphate ions and the effectiveness of enamel remineralization is reduced (Szkaradkiewicz-Karpinska AK et al, 2024). Therefore, the balance between demineralization and remineralization shifts towards loss.

Among the aggravating factors, it is important to consider the frequent intake of fermentable sugars/carbohydrates, which lower the pH of plaque (Hassan H, et al, 2015).

A diet low in alkalizing elements and low intake of water/alkalizing minerals also contribute to maintaining an excessively low pH.

In addition, reduced salivary flow (xerostomia, medications, diseases) is associated with lower buffering capacity.

Systemic conditions such as diabetes and gastroesophageal reflux increase the frequency of oral acidity.

6. FACTORS THAT CONTRIBUTE TO A PROPER PH BALANCE IN THE ORAL CAVITY

A proper pH balance in the mouth is essential for maintaining healthy teeth and gums, preventing tooth decay, enamel erosion, and periodontal disease.

The main factors that promote a balanced salivary pH (neutral or slightly alkaline, ~6.8–7.4) are:

1. Adequate saliva production

Saliva is the main buffering mechanism in the oral cavity. It is stimulated by chewing, hydration, and eating fiber-rich foods. When saliva is alkaline (rich in bicarbonate, phosphates, calcium), it neutralizes acidity.

2. Alkalizing diet

Prevalent consumption of fresh fruits and vegetables rich in alkaline minerals (e.g., magnesium, potassium).

Combined with limiting simple sugars, acidic beverages (industrial juices, soft drinks), coffee, alcohol, and red meat, this helps prevent the salivary pH from dropping excessively.

3. Proper oral hygiene

It is essential to remove plaque, which can acidify the oral environment through bacterial fermentation.

The presence of dental plaque (biofilm) promotes the fermentation of carbohydrates and the production of local acids, which reduce the pH of plaque and saliva. One study showed that in subjects with abundant plaque, the decrease in salivary pH was more pronounced (Kumar A et al, 2011).

Another study showed that when saliva flow or buffering capacity was limited, biofilm microenvironments had lower pH values, especially in regions with dense or thickly accumulated plaque (Kristensen MF et al, 2021).

Less plaque means a smaller “reservoir” of residual sugars and acidic metabolites that continue to stimulate low pH. For example, the study “Role of plaque in the clearance of salivary sucrose and its influence on salivary pH” shows that the presence of plaque prolonged sugar clearance time and lowered salivary pH for longer (Kumar A et al, 2011).

With less plaque, saliva has better access to dental sites, allowing for better buffering action, more effective distribution of bicarbonate/phosphate ions, and a faster return to neutral pH after an acid challenge.

The study “The effect of saliva on plaque pH in vivo” showed that good saliva works best when plaque is minimal: the presence of biofilm reduces the ability of saliva to “restore” pH (Abelson DC, Mandel ID., 1981).

In this regard, the use of non-aggressive toothpastes and mouthwashes with a neutral or slightly basic pH is recommended.

Based on evidence and oral physiology, it can be said that mouthwashes that neutralize acidity after exposure to food acids are useful (study on “neutralizing mouthwash” after acidic juice) (Dehghan Met al, 2017). Mouthwashes should contain ingredients that support salivation or buffering capacity: for example, solutions that stimulate saliva production or contain bicarbonate/carbonates. In an RCT on children, a probiotic mouthwash was shown to increase salivary pH more effectively than a traditional mouthwash in 7 days (Talmale R. et al, 2025).

Among toothpastes, those containing remineralizing minerals (Ca, phosphates, tricalcium phosphate, ACP, CPP-ACP) and with an alkaline pH are preferable, as they increase the salivary concentration of mineral ions and simultaneously improve salivary pH (Sharma E et al, 2012;). A

randomized study showed that 42 days of use of “remineralizing” toothpastes (containing functionalized tricalcium phosphate or casein phosphopeptide/ACP) for 42 days compared to standard toothpaste resulted in a significant increase in salivary pH, along with an increase in salivary Ca and phosphate (Sharma E et al, 2012).

On the other hand, toothpastes or mouthwashes that further lower the oral pH (e.g., if they contain acidifying agents or high alcohol content) should be avoided.

We must also remember that the increase in pH achieved with mouthwashes/toothpastes may be temporary, especially immediately after use, and does not replace consistent oral hygiene and a pH-friendly diet.

4. Chewing and mechanical stimulation

This promotes salivary secretion: chewing slowly and eating fibrous foods increases salivary flow.

It mechanically stimulates the salivary glands: when chewing, receptors in the periodontium, oral mucosa, and gums are activated, sending nerve signals (masticatory reflex) to the salivary glands to increase secretion (Müller, F et al, 2023).

A review explained that food intake and chewing are strong stimuli for the salivary glands: “Ingestion of food and beverages, in turn, is a strong stimulus for secretion of saliva” (Pedersen et al., 2018).

Harder foods or foods that require more chewing (more chewing cycles) induce greater salivary stimulation than softer or pre-chewed foods, due to the greater contact surface of the food and chewing time (van der Bilt A et al, 2007). A study of 16 healthy subjects found that chewing natural foods increased the rate of saliva secretion compared to non-food stimuli (e.g., parafilm), indicating that the strength and nature of food stimulate salivary secretion more (Gavião MB, Bilt AV, 2004).

The taste, texture, and sensory stimulation associated with chewing amplify salivary secretion. A meta-analysis showed that the simple act of chewing (sugar-free gum) leads to a significant increase in unstimulated salivary flow in elderly subjects or those with xerostomia (dry mouth): SMD = 0.44 (95% CI 0.22-0.66; p = 0.00008) compared to control (Dodds MWJ et al, 2023).

Increased salivary flow contains more bicarbonate and phosphate ions, which help neutralize acids thanks to their buffering effect, and thus also contribute to the regulation of oral pH.

5. Adequate hydration

Good hydration, especially with alkalizing liquids, keeps saliva fluid and active.

It supports the function of the salivary glands, maintains fluid and abundant saliva rich in electrolytes, and prevents conditions that predispose to caries, gingivitis, halitosis, and digestive disorders.

It is important to drink at least 1.5–2 liters of water per day, more in case of physical activity or hot weather, avoid dehydrating beverages such as caffeine and alcohol, which reduce salivary secretion, and monitor oral dryness, especially in the elderly and in individuals taking xerogenic medications.

Rai B et al. observed that well-hydrated individuals have higher salivary levels, better buffering capacity, and a lower risk of oral diseases (Rai B et al., 2011).

6. Avoid smoking

Smoking reduces the quantity and quality of saliva and alters the oral bacterial flora.

Tobacco smoking has well-documented effects on reducing the quantity and quality of saliva, as well as altering the oral bacterial flora, increasing the risk of oral diseases.

Clinical studies have shown that chronic smoking is associated with hypofunction of the salivary glands: smokers show a significant reduction in salivary flow compared to non-smokers (Gomes-Filho IS et al., 2010).

Smoking also alters the composition of saliva, reducing the concentration of protective enzymes

(such as salivary amylase and peroxidase) and decreasing the buffering capacity and antimicrobial efficacy of saliva. According to Reznick AZ et al., smoking induces oxidative stress in saliva, reducing levels of salivary antioxidants such as glutathione (Reznick AZ et al., 2003).

Smoking alters the oral bacterial flora, creating an anaerobic and acidic environment conducive to the growth of pathogenic bacteria such as *Porphyromonas gingivalis* and *Tannerella forsythia*.

In fact, smokers have a different oral biofilm composition, with a higher presence of pathogenic bacteria (Kumar PS et al., 2011), in addition to an impairment of the local immune system's ability to control the bacterial flora (Niederman R et al., 1997).

Smoking is one of the main modifiable risk factors for early tooth loss: it causes an increased risk of periodontitis, caries, halitosis, xerostomia, and a reduced response to periodontal or oral surgical treatments (Tomar SL, Asma S, 2000).

7. Avoid chronic stress

Stress can reduce salivation and alter the oral microbiota.

Stress activates the autonomic nervous system (particularly the sympathetic branch) and the HPA (hypothalamic-pituitary-adrenal) axis, increasing hormones such as cortisol that can affect salivary secretion and saliva composition (Paudel D et al, 2022).

Reduced salivary secretion leads to lower salivary flow, decreasing the buffering capacity of saliva, altering the local pH balance, and reducing the dilution and removal of bacteria and metabolic products.

Changes in saliva (lower volume, protein alteration, change in osmolarity) alter the habitat for oral bacteria, favoring more opportunistic or pathogenic bacteria and altering the microbial composition.

One study has shown that psychological stress alters the salivary glands (morphological changes in acini and ducts) and the composition of saliva, and these alterations can in turn modulate the oral microbiota (Paudel D et al, 2022).

Reduced salivation and alteration of the bacterial flora increase the risk of caries, periodontal disease, and halitosis because the natural salivary defenses (bicarbonate, phosphates, antimicrobial enzymes) are compromised.

Stress can therefore represent a modifiable risk factor for oral health, in addition to more well-known factors such as hygiene and diet.

A study of male students with chronic stress found that stressed subjects had increased production of volatile sulfur compounds in their breath and an increase in the population of bacteria such as *Solobacterium moorei* in their saliva, compared to non-stressed subjects (Nani BD et al, 2017).

A review emphasized that saliva plays a key role in oral microbiological composition and that “dysbiosis can occur rapidly if salivary flow is disrupted” (Marsh PD et al, 2000).

7. PH MEASUREMENT

Different pH meters validated by scientific literature and currently on the market were compared. The pH meters analyzed were:

- Laquatwin ph-11 Horiba Instruments
- pH Meter HI99192 Hanna Instrument
- pH Meter Lutron
- Litmus Paper
-



Figure 1 - pH meters analyzed

It was rated:

- their degree of reliability and precision
- manageability and ease of use
- the cost-benefit ratio
- the possibility of monitoring over time

Salivary pH assessments were carried out at the beginning of the day the and end of each meal. The pH evaluation after each meal must be carried out within 5 minutes, max 10, because then the buffer capacity of the saliva brings the pH back to its normal balance.

Urinary pH assessments were carried out twice a day, at the beginning and end of the day, in order to plan changes in eating and lifestyle behaviors for the following day.

All electronic devices were characterized by a high degree of reliability, but the handling and ease of use is limited by the fact that the positioning of the sample occurs either with a dropper or by immersion in a container.

Data management is possible but not immediate as it could happen with reading via smartphone application.

Based on these analyzes and considerations and after reviewing of existing literature to understand the methods, timing and frequency of pH monitoring and how to evaluate the buffering effect of saliva, we evaluate one commercially available pHmeter, to provide a group of patients with an easy-to-use tool.

We choose litmus papers for the many advantages they offer: great affordability, great practicality, easy transportability, and evidence-based reliability. Litmus papers do not allow for highly precise measurement; we need an instrument that indicates whether the pH is acidic, neutral, or basic, and roughly how much.

7.1 Litmus paper for measuring urinary pH

Urinary pH test strips are papers impregnated with colorimetric indicators that change color depending on the concentration of H^+ ions present in the urine. They are widely used for rapid, “field” use because:

- they are inexpensive;
- they are easy to use without complex equipment;

- they are accurate for screening or frequent monitoring.

However, they have limitations in terms of accuracy, sensitivity, and repeatability compared to electrochemical laboratory methods.

In the study “Accuracy of urine pH testing in a regional metabolic renal clinic: is the dipstick accurate enough?”, it was found that, although practical, the strips can give values that differ significantly from the dialectical value of the electrode.

Validity refers to how well the instrument measures what it is supposed to measure (i.e., the actual pH of urine).

A study on strips read by “non-professional” users showed greater bias: in “Evaluation of a Portable Urinary pH Meter and Reagent Strips,” the average differences were: professional with bias -0.09 , non-professional user bias -0.17 , automatic strip reader bias -0.29 pH units (De Coninck V et al, 2018).

The strips measure in “steps” (usually 0.5 pH units) and the color to be interpreted may be subject to visual variability, ambient light, and subjects with visual impairments.

The greatest errors were found in extreme pH values (very acidic or very alkaline): the strips tended to underestimate or overestimate the actual values (e.g., in the clinical study: $\text{pH} > 6.5$, the strips overestimated) (De Coninck V et al, 2018).

Urine pH varies throughout the day due to diet, hydration, and kidney conditions: using a single “spot” measurement can be misleading (Abbott JE et al, 2017).

The strips are not a substitute for a pH meter in clinical settings where therapeutic decisions are at stake (e.g., urinary pH manipulation therapy in kidney stones) because errors can lead to incorrect decisions.

Litmus paper is recommended for:

- Home screening or frequent non-clinical monitoring to see rough pH trends (e.g., “trend toward acidity” vs. “trend toward alkalinity”). This is the case in our study.
- Use in contexts where extreme precision is not required, but guidance is (e.g., self-management wellness models). This is the case in our study.

Not recommended as the sole diagnostic tool if ± 0.2 pH unit precision or specific medical decisions are required: in these cases, a pH meter or laboratory test is preferable.

Urinary pH strips (litmus paper/reagent strips) are useful, convenient, and easy-to-use tools, but they have significant limitations in terms of accuracy and reproducibility. Studies indicate that the error can be clinically relevant in about a quarter of measurements in specialist contexts. They are fine for general wellness and non-clinical monitoring purposes, as long as it is understood that they give an approximate indication of urinary pH and that trends and consistent use are more important than the specific value.

7.2 Litmus paper in salivary pH measurement

In oral health or point-of-care settings, they are used to measure pH in saliva, urine, or other biological fluids. For example, a review indicated that pH strips are “low-cost, non-invasive, with instantaneous results” tools useful in oral medicine (Shamsi-Basha B et al, 2024).

In dentistry, too, the strips are practical for everyday use because they do not require complex instruments and allow direct visual reading of the pH via a color scale.

A specific study on ocular measurements showed that litmus papers exhibit significant variability between operators: in 5% of cases, measurements differed by more than 2.39 pH units between two

people. (Monaghan MT et al, 2020).

The review “Evidence-Based Practice for the Use of pH Indicator Paper Strip in Oral Medicine” indicates that “the lack of sensitivity of pH paper must be underlined” or, in other words, the strips can give a general indication but are not always as sensitive or accurate as an electronic meter. The study also found that, although the papers may have acceptable reproducibility in certain cases (e.g., unstimulated saliva), there are conditions that reduce their reliability: for example, non-standardized samples, fluid variability, and color that is difficult to interpret. Furthermore, in the context of biological fluids and field measurements, the correlation between litmus paper and pH meters is often only “moderate.” In the ocular study, the correlation was ~ 0.59 , and the concordance was ~ 0.54 .

The characteristics of litmus paper in the dental field are therefore:

- a. good reliability with poor accuracy: the paper provides a quick estimate of pH, but does not guarantee the accuracy of a digital meter/electrode. For critical or clinical values, confirmation with more accurate instruments is necessary.
- b. Validity: if the purpose is simply to identify whether the pH is “very acidic” vs. “normal or alkaline,” the strip can be useful. However, if you want to accurately measure moderate variations (e.g., 6.2 vs. 6.5), its use becomes less valid.

Firstly, optimal conditions of use are those of using samples under standard conditions (e.g., unstimulated saliva, fasting, clean samples)

Secondly, you need to ensure that the paper, color reference, and environment (lighting, paper exposure) are in good condition. Visual inspection indicates that paper exposed to light, moisture, or age impairs accuracy.

Color interpretation is subject to subjective variability, particularly with unclear color scales or users with visual impairments.

A review suggests that in dentistry, salivary pH assessment with paper strips can be used as a quick chair-side test, especially in cases of early childhood caries (ECC) or severe periodontitis (Shamsi-Basha B et al, 2024).

7.3 Possible Confounding Factors in Daily Self-Monitoring of Salivary and Urinary pH Using Litmus Strips

1. Biological and Physiological Variability

- a. Natural fluctuations in salivary pH: salivary pH changes throughout the day depending on intrinsic physiological processes, such as circadian rhythms, salivary flow rate, gland function, and autonomic nervous system activity. These changes can occur even in otherwise healthy individuals, making it difficult to interpret a single daily measurement as a stable marker of health.
- b. Urinary pH variability: urinary pH is also subject to diurnal variation and renal regulation mechanisms. This variability arises from factors including metabolic processes and kidney function, so spot measurements may not reflect overall acid–base status. Normal physiological variability may overshadow meaningful health-related changes.

2. Timing of Sample Collection

- a. Influence of collection timing: the time of day, how long since waking, and recent behaviors (e.g., eating, drinking, physical activity) influence salivary composition and pH measurements. For example, one study noted that socio-behavioral factors (time since waking, time of day) are linked with variability in salivary collection metrics, which could bias biological measurements (Mariko et al, 2023).
- b. Diet and recent intake: food and fluid consumption directly affect both salivary and urinary pH immediately after ingestion. Measuring pH too soon after meals or beverages — whether acidic or

alkaline — will confound interpretation of chronic or baseline pH.

Inconsistent timing relative to meals and daily rhythms introduces systematic measurement bias.

3. Dietary, Hydration, and Lifestyle Influences

a. Food and drinks alter pH: salivary pH is strongly influenced acutely by food and beverages consumed. For example, acidic foods can lower pH, whereas buffering foods temporarily raise pH (Pachori et al, 2018).

Similarly, urine pH is affected by caloric intake, water consumption, and nutrient composition, with studies showing water intake can significantly change average urine pH values (Chavez et al, 2023).

b. Hydration status: hydration affects both salivary flow and urine dilution, leading to shifts in pH readings that reflect fluid balance rather than underlying health.

Diet and hydration patterns may dominate short-term pH changes independent of disease processes.

4. Local Oral and Microbial Factors

Microbial activity and plaque: oral microbial metabolism (e.g., bacterial fermentation of sugars) changes local pH rapidly and transiently. The presence or absence of dental plaque and oral hygiene practices affect measurements more than systemic disease.

Local oral microbiome and hygiene factors cause salivary pH shifts unrelated to systemic physiology.

5. Stress, Behavior, and Systemic Influences

a. Psychological stress:

Salivary pH responds to sympathetic and parasympathetic nervous system activity and has been investigated as a stress biomarker — meaning emotional state may alter pH independently of oral or systemic pathology (Cohen M et al, 2014).

b. Physical activity:

Levels of recent exercise or caffeine intake also influence salivary composition and pH, and these behaviors vary widely day-to-day.

Stress and recent physical behavior affect salivary pH without direct relation to health conditions.

6. Technical and Measurement Limitations

a. Litmus strip accuracy:

Home pH test strips provide approximate values that depend on color interpretation, lighting conditions, and strip quality. They lack the precision of laboratory instruments. Even small differences in color perception can yield divergent readings, reducing reliability.

b. Collection method differences:

Whether saliva is stimulated (by chewing, rinsing, eating) or unstimulated changes its composition and pH. Without strict protocol, variability in collection mimics health changes but is simply methodological noise.

Instrument precision and technique biases can overshadow true physiological differences.

8. MOBILE APP

According to Bidmon S et al, a mobile app is “a software application developed for mobile devices with user interfaces optimized for touch and functions designed for mobile use” (Bidmon S et al, 2014).

There are three main categories:

1. *Native apps*: these are developed for specific operating systems (iOS, Android) and use the device's native language (e.g., Swift for iOS, Kotlin for Android). They offer better performance and direct access to hardware (Nguyen et al., ACM Computing Surveys, 2019).
2. *Web apps*: these are accessible via a mobile browser and do not require installation.
3. *Hybrid apps*: these combine elements of native and web apps and are built with technologies such as HTML/CSS/JavaScript (e.g., with frameworks such as Ionic or React Native).

Among the advantages of a mobile app is the ability for users to access services anywhere and at any time. The study by Tsai et al. showed that apps improve user engagement, especially in areas such as health, fitness, and learning (Tsai et al., 2017).

Finally, they allow for personalization: users can receive notifications, personalized suggestions, and generate a collection of data (with consent).

8.1 Telemedicine

The use of apps in the healthcare sector falls under what is known as telemedicine. Telemedicine is the remote delivery of healthcare services using digital technologies such as video calls, mobile apps, connected devices, and online platforms. It allows for diagnosis, monitoring, consultation, and clinical management without the need for a physical meeting between patient and doctor (Smith et al., 2020).

In recent years, the use of telemedicine has increased dramatically worldwide. This trend has been driven by the need to provide better access to healthcare services in rural areas or areas with a shortage of specialists (Dorsey and Topol, 2020) and by the development of technological innovations that have made remote doctor-patient communication easier and safer (Kruse et al., 2018).

Telemedicine offers numerous advantages:

1. *Improved accessibility*: it allows patients in rural areas or with reduced mobility to easily access medical services (Dorsey & Topol, 2020).
2. *Cost reduction*: decreased expenses related to transportation and on-site visits, with savings for patients and healthcare systems (Bashshur et al., 2016).
3. *Continuous monitoring*: enables more consistent monitoring of chronic diseases with apps and remote devices (Kvedar et al., 2014).
4. *Reduced risk of infection*: particularly important during a pandemic, avoiding exposure in crowded places (Smith et al., 2020).
5. *Convenience and flexibility*: faster appointments and easier remote management (Kruse et al., 2017).

However, it also has limitations, such as:

1. *Technical limitations*: connectivity issues and lack of familiarity with technology on the part of some patients (Hilty et al., 2013).
2. *Clinical limitations*: some diagnoses require physical examinations or tests in person, which are

not always possible remotely (Greenhalgh et al., 2020).

3. *Privacy and security*: there is a risk of data breaches and a need for regulatory compliance (Kruse et al., 2017).

4. *Disparities in access*: exclusion of those without digital devices or skills (Nouri et al., 2020).

5. *Doctor-patient relationship*: potential reduction in the quality of the empathetic relationship (Shaw et al., 2020).

8.2 mHealth-mobile Health apps

Health monitoring apps, otherwise known as remote patient monitoring, are systems in which healthcare professionals can monitor the health of their patients remotely. This allows for easier management of chronic diseases beyond the walls of hospitals or clinics.

According to Maaß L et al, health apps are software programs on mobile devices that process health-related data about or on behalf of their users. They can be used by anyone who is health-conscious to maintain, improve, or manage the health of an individual or community (Maaß L et al, 2022).

These apps help track all kinds of activities related to a patient's health. In addition, users can set a goal to achieve their health objectives and measure previous activity data along with current data to improve the way they live their lives and modify their lifestyle.

The features that a health app must have are as follows:

1. Data recording and monitoring functions

For example, in a study of patients with heart failure, the planned app allowed daily recording of symptoms, vital signs, weight, sending alerts, and graphical display of data (Davoudi M et al, 2020).

A systematic review of chronic conditions also found that the feedback and monitoring function was present in 91% of the apps analyzed (Cucciniello M et al, 2021).

2. Usability, simple and intuitive interface

One study highlighted that the features that contribute positively to user ratings are: ease of use (usability), data export, and the presence of plans/orders within the app (Mendiola MF et al, 2015).

Another recent review emphasized that “a simple and intuitive interface... minimum manual input... in-app educational content” are features associated with greater usability (Deniz-Garcia A et al., 2023).

3. Integration with devices or data export functions

Successful apps allow data to be exported or shared with healthcare professionals or caregivers (Mendiola MF et al, 2015).

4. Educational content and user guidance

Many apps include information sections, instructions, videos, and educational materials for managing health conditions. For example, in the study on rare diseases, 52% of apps included “web-based information for patient education” (videos, databases, fact sheets) (Hatem S et al, 2022).

5. Behaviour Change Techniques (BCTs)

The apps analyzed featured various BCTs on average: for example, forms of feedback/monitoring, shaping knowledge (Cucciniello M et al, 2021).

6. Push messages, reminders, alerts

Apps designed for chronic conditions often include reminders for medications, measurements, and activities to be performed (Davoudi M et al, 2020).

These apps have several strengths.

First, they allow for continuous and personal monitoring of health data. This gives patients greater awareness and can support the independent management of chronic conditions.

Well-designed apps with a simple interface and good educational support tend to be rated more highly by users.

They also enable concrete clinical improvements: in some systematic studies, the use of apps has led to clinical improvements (e.g., reduction in HbA1c in diabetics) (de Souza Ferreira, E et al, 2023).

On the other hand, the critical issues are that the overall quality of apps is often medium to low: in one review, the potential for behavioural change was “low to moderate” (Bricca A et al, 2022).

Furthermore, many apps do not follow formalized development standards, do not involve users or healthcare professionals in their design, and have limited evaluation methodologies (Cucciniello M et al, 2021).

Finally, if not well designed, the ‘tracker/pure recording’ function can be a deterrent to continued use by the user (Mendiola MF et al, 2015).

8.3 AI in mHealth apps

The integration of AI into health monitoring apps represents a great opportunity to offer active monitoring, personalization, immediate feedback, and decision support. However, many factors are needed to translate this potential into reliable clinical results: rigorous validation of algorithms; transparency and explainability (“explainable AI”); attention to privacy, usability, and equity of access; user-centered design with adequate participation of healthcare professionals.

AI can perform several tasks in this area of application:

1. Predictive analysis and continuous monitoring

AI-based apps use machine learning algorithms to analyze patient data (vital signs, activity, wearable sensors) and predict risks or abnormalities. For example, one study showed that apps with AI symptom checkers are able to suggest possible conditions based on symptoms entered by the user (Zawati MH, Lang M., 2024).

Another study evaluates the spread of AI apps for daily well-being and health monitoring, highlighting the expansion of data-driven use (Yang, F et al, 2025).

2. Automation and personalization of interaction

AI apps offer chatbots, personalized recommendations, automatic feedback, and adaptation to user behavior. A study on mental health apps for children found that many apps use AI for dialogue, journaling, and behavioral support (Alduhailan, H. W et al, 2025).

3. Quality and usability assessment

A specific study compared three AI-powered apps (ADA, Mediktor, WebMD) in terms of usability and transparency: it found that, despite being widely used, they show shortcomings in terms of explainability of AI outputs, user feedback, and transparency (Deniz-Garcia, A et al, 2023).

4. Privacy, regulation, and bias

AI apps raise ethical and technical issues: bias in algorithms, lack of transparency, and personal data protection.

Several limitations to the use of health apps based exclusively on AI monitoring have therefore emerged:

- *Uncertain clinical reliability:* the quality of algorithms and clinical validation often remain

insufficient; some outputs lack justification or understandable explanation (Deniz-Garcia, A et al, 2023).

- *Usability and user trust*: even reputable apps have problems providing clear feedback, handling input errors, and explaining recommendations (Alduhailan HW et al, 2025).
- *Accessibility and digital divide*: the use of AI requires adequate hardware, data connection, and digital skills; this may exclude vulnerable segments of the population.
- *Privacy and data security*: many apps do not comply with data transparency policies or allow little visibility into the use of AI and models (Yousra Javed, Saaketh Bhojanam, 2025).
- *Regulation*: the rapid development of AI apps in healthcare often outpaces existing regulations, with risks of unvalidated or self-promoted applications (Zawati MH, Lang M., 2024).

9. DESIGNING A MOBILE APP

Creating an app (mobile app) is a complex process that requires design, development, testing, and distribution. Below, I explain in detail, step by step, how to create an app, both from a technical and organizational point of view, including tools, languages, and skills.

9.1 Defining the idea and the problem

We must first define the objectives, understand who the user is and who the competitors are.

9.1.1 Objective: What does the app solve? What need does it meet?

The function of this application is to enable a change in the user's lifestyle, using a parameter that summarizes the person's general state of health in order to prevent the onset of inflammatory or degenerative diseases.

It is a tool based essentially on primary prevention: encouraging healthy individuals to avoid the onset of diseases by exploiting the body's self-healing abilities, resources that every individual possesses and which are effective when the immune system is not overloaded with information that disrupts the balance of health: poor diet, unhealthy lifestyle habits, lack of exercise, etc.

This application encourages users to follow a healthier lifestyle, using daily pH monitoring as objective data on which to base the adoption of new dietary and behavioral practices.

9.1.2 Target: Who is the end user? Which platform (iOS, Android, or both)?

The end user is a healthy individual who wants to prevent diseases that could impair their quality of life.

They may be aged 14/15 and above, which is the normal age of those who now own a personal smartphone and can use it daily to monitor their pH.

The chosen platforms can be either iOS or Android: given the simplicity of the application, it can be offered for both platforms.

9.1.3 Competitor analysis: What similar apps exist? What can you do better or differently?

There is currently only one app dedicated to monitoring urinary pH. It is the first urine scanner to be connected to the toilet and is designed to analyze various health indicators through urinary biomarkers.

Introduced to the market in October 2025, the Withings U-Scan Nutrio device allows personal health monitoring, integrating technology and practicality directly into the toilet.

It is a device installed in the toilet that automatically analyzes urine and transmits the data to the application.

It allows the detection of multiple biomarkers: for the Nutrio version, the device measures urinary pH, which can reflect acid-base status, hydration (specific gravity), ketones, and vitamin C.



Figure 2a. Withings U-Scan Nutrio device

It is hands-free/automatic: once installed and configured, users report that it is relatively simple and non-invasive.

The stated technical specifications are good: for example, the manufacturer reports that for urinary pH, the repeatability of the test is high ($\approx 98\text{-}100\%$ within ± 1 block) in internal tests.

Among the weaknesses is certainly a high price, with recurring subscriptions for cartridges and access to advanced features. It is therefore only accessible to a wealthy segment of the population, both in terms of the purchase of the sensor itself and the refill cartridges (basic package price: 2 measurements/week: €349.95 intensive package price 5 measurements/week: €429.96)

There is also no clinical design or approval as a medical device: it is stated that “the device is not a medical device” and there are no independent peer-reviewed studies on its complete effectiveness/accuracy in real-world settings.

It also has limitations in real-world settings: for example, the device is for single-user only, it requires a WiFi connection, and some users report problems with installation or operation in the toilet (e.g., the need for sufficient water pressure). The device does not support multiple users, which makes it somewhat inconvenient in shared households.

It also limits assessment to the home environment, interrupting continuous monitoring in the event of travel or stays in other contexts where the device is not present.

It also requires users to urinate in a seated position, which may be uncomfortable for some males.

Finally, the device can be affected by interference from normal toilet cleaning products, which can alter the accuracy of the monitoring parameters.

Existing oral health monitoring apps are mainly based on monitoring and education on proper oral hygiene.

There is currently only one study by Arroyo MJ et al. that uses Point-of-Care (POC) platforms in combination with a smartphone. POC devices are designed for home or clinical use and provide real-time results for immediate diagnosis and treatment. Lateral flow devices, equipped with a paper core, and other saliva-based POC systems have been widely used for the diagnosis of SARS-CoV -2 by patients or healthcare workers during the pandemic (Arroyo MJ et al, 2024).

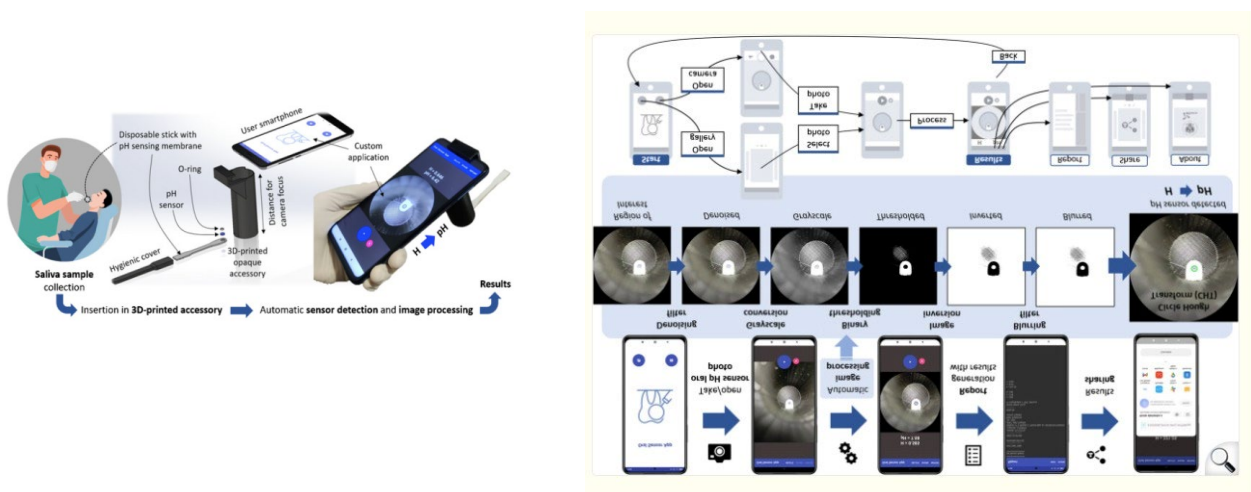


Figure 3. Arroyo et al Prototype

The pH is detected using a disposable stick to collect saliva based on chitosan with water-soluble

anthocyanin extract, non-toxic natural dyes, and pH-sensitive compounds.

By combining a membrane that changes color in response to oral pH with a smartphone capable of capturing and processing an image of that membrane, pH determination is performed.

By using the camera flash to capture images, the lighting conditions in which the pH sensor is always photographed are constant, ensuring consistent results regardless of external lighting conditions. The device is based on acidochromism originating from a sensor, which employs an immobilized acidochromic indicator dye as a recognition element. This processing involves the use of circular Hough transform (CHT) to detect the circular colorimetric sensor. CHT is a feature extraction technique used in digital image processing to identify circular objects in imperfect digital images (Kimme C et al, 1975).

The limitations of this method are the need for an accessory to be attached to the smartphone in order to photograph the stick, as well as requiring chitosan-based sticks with water-soluble anthocyanin extract, which are not easily available on the market.

10. HpH app

We decided to name the app “**Human pH - HpH**” because it analyzes the pH of the most easily assessable fluids, urine and saliva, using a simple, inexpensive, readily available, and easy-to-use tool.

The name is easy to remember and understand: we take care of human health through the non-invasive monitoring of a simple parameter, pH.

There are currently no applications that simultaneously analyze these two parameters, which are linked by lifestyle habits such as nutrition and hydration.

We defined a sample of patients to whom we administered evaluation questionnaires with the aim of defining which parameters were necessary for the creation of a pH monitoring app.

A sample group of 50 patients was defined with the following inclusion and exclusion criteria:

- age between 15 and 80 years of age
- DMFT index less than 5
- interest in the pilot project and in a possible change in their habits
- absence of previous pathologies capable of affecting the evaluation of the pH variation

First, information was provided regarding:

1. which factors contribute to the lowering of pH: acidic nutrition, poor hydration, poor physical movement, high levels of stress
2. how to modify the above-mentioned factors with a change in lifestyle
3. how and when to monitor salivary and urinary pH levels during the day

Secondly, we administered questionnaires, a user survey, to assess:

1. whether or not patients were interested in an app for lifestyle changes and monitoring their general and oral health
2. whether or not they were aware of the usefulness of pH measurement
3. whether they were interested in a generic app or one with customization options

10.1 Creating a User Survey

A user survey is a structured questionnaire that is administered to a group of people (users or potential users of a product, service, or app) to collect information, opinions, feedback, or specific data.

In practice, it is a fundamental tool for better understanding your audience and improving your offering.

The main purposes of a user survey are:

1. To understand needs, preferences, and behaviors.
2. To evaluate satisfaction with a product or service.
3. To identify problems or areas for improvement.
4. To gather ideas for new features or services.
5. To measure the effectiveness of campaigns or changes.

The characteristics of a good user survey are:

1. Clear and concise questions.
2. A balance of closed questions (multiple choice, rating scale) and open questions (free responses).

3. Short and quick to complete to maximize participation.
4. Respect for privacy and anonymity (if necessary).

10.1.1 HPH Survey

We first provided information to the participants in the sample group and then the actual questionnaire.

a. Information provided:

1. Factors Contributing to Lowering pH

Several lifestyle factors can contribute to more acidic urinary and salivary pH levels (lowering of pH):

- *Acidic diet:* A diet rich in acid-producing foods, such as red meat, fish, cheese, and refined grains, can lower urinary and salivary pH. Conversely, fruits and vegetables tend to produce alkaline waste products that raise pH.
- *Poor Hydration:* Insufficient fluid intake leads to more concentrated and more acidic urine. Chronic dehydration can also reduce salivary flow, contributing to a more acidic oral environment.
- *Reduced Physical Activity:* Although short-term intense exercise can temporarily lower salivary pH, regular physical activity generally contributes to a better metabolic balance. A sedentary lifestyle may be associated with less efficient management of metabolic acids by the body.
- *High Stress Levels:* Psychological stress and anxiety have a significant effect on reducing salivary flow, which in turn leads to a reduction in saliva pH.

2. How to Modify Factors with a Change in Lifestyle

It is possible to modify these factors to promote a more balanced pH:

1. Modify Your Diet:

- Increase your consumption of fruits and vegetables (alkalizing foods).
- Reduce your intake of red meat, cheese, and processed foods.
- Limit your consumption of sugary and acidic beverages, such as carbonated drinks.

2. Improve Hydration:

- Drink adequate amounts of water throughout the day (aim for 1.5-2 liters per day, but the amount varies depending on activity and climate).
- Drink mineral water during physical activity instead of acidic sports drinks.

3. Increase Physical Activity:

- Integrate regular physical activity into your daily routine to improve overall metabolism and acid waste management.
- Avoid excessive overtraining, which can have counterproductive effects on hormone levels (cortisol).

4. Manage Stress:

- Practice relaxation techniques such as meditation, yoga, or deep breathing.
- Ensure adequate sleep quality and quantity, as sleep affects stress levels and saliva production.

3. How and When to Monitor Salivary and Urinary pH Levels

pH monitoring can be easily done at home using test strips.

Urinary pH

- *How:* Use a test strip and compare the color to the scale provided.
- *When:* First thing in the morning, urine is generally the most concentrated and is a good indicator of the body's overall acid-base status after a night's rest (ideal value 6.5-7.5). It is also useful to test urinary pH at the end of the day to see how it responds to your diet.

Saliva pH

- *How:* Apply the test strip directly to saliva.
- *When:* Early in the morning or 2 hours after meals. Saliva pH varies naturally throughout the day, with minimum values in the early morning and maximum values in the afternoon/evening. It is important to measure under standard conditions (e.g., not immediately after brushing your teeth or drinking liquids other than water) to obtain consistent results.

b. User Survey

A quick and easy questionnaire was then proposed: it consists of 8 questions and gives us general guidelines for the design of the app.

1. How useful do you think an app dedicated to lifestyle change is?

- Not useful at all
- Not very useful
- Quite useful
- Very useful

2. How often do you measure your urinary or salivary pH?

- Never
- Rarely (less than once a week)
- Often (2-4 times a week)
- Daily

3. How useful do you think pH monitoring is for your overall health?

- Not at all useful
- Not very useful
- Quite useful
- Very useful

4. How useful do you think pH monitoring is for your oral health?

- Not at all useful
- Not very useful
- Quite useful
- Very useful

5. What are your reasons for using or wanting to use an app of this type?

- Disease prevention
- Improving nutrition
- Monitoring oral health
- Others _____

6. What features would you like to see in a pH monitoring app? (you can choose more than one)

- Test reminders
- Personalized dietary advice/recipes/video tutorials
- Personalized training advice/video tutorials
- Weekly/monthly reports
- Expert support
- User community
- Lists of foods and waters with their pH

7. Would you be willing to pay for a premium version of the app with advanced and personalized features (monitoring of your nutrition, hydration, breathing, physical activity, and oral health by a team of experts)?

- No, I prefer the free version
- Yes

8. What is the most suitable age range for users of this app?

- <18
- 18-30
- 31-45
- 46-60
- >60

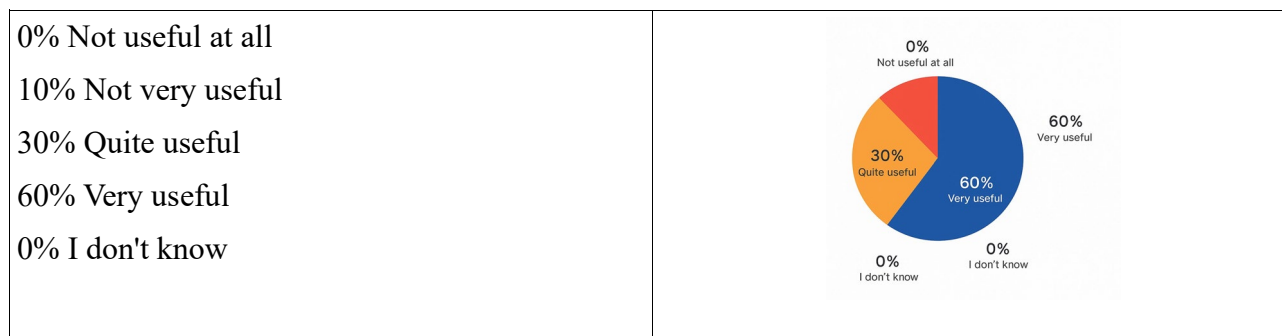
10.1.2 Survey administration

The questionnaire was administered to a sample of 50 patients, defined by the following inclusion and exclusion criteria: possession of a personal smartphone, interest in the pilot project and in a possible change in their habits, absence of previous pathologies that could influence the evaluation of pH variation.

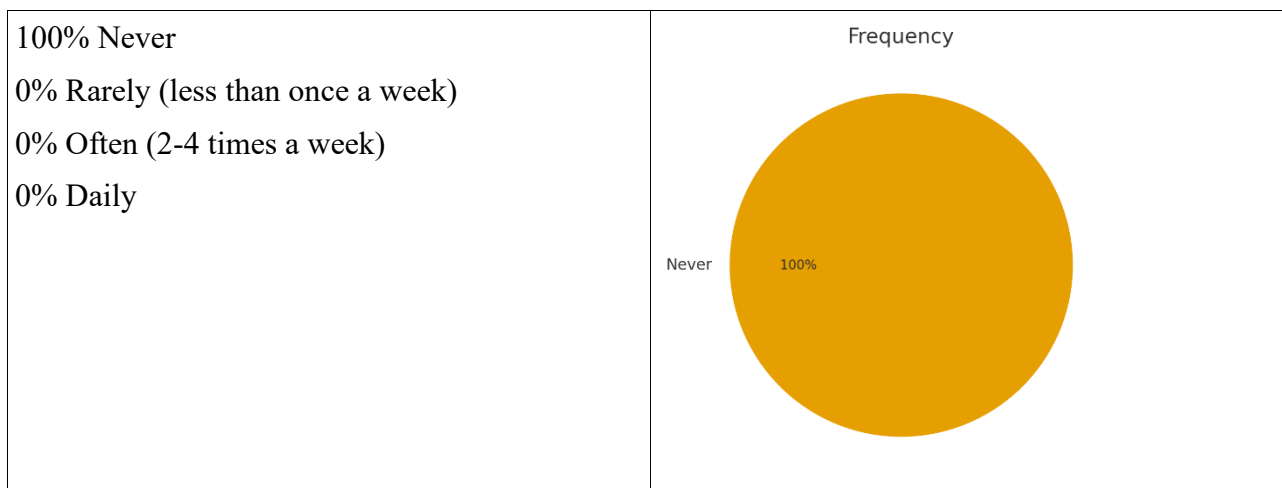
10.1.3 Results

The results were as follows:

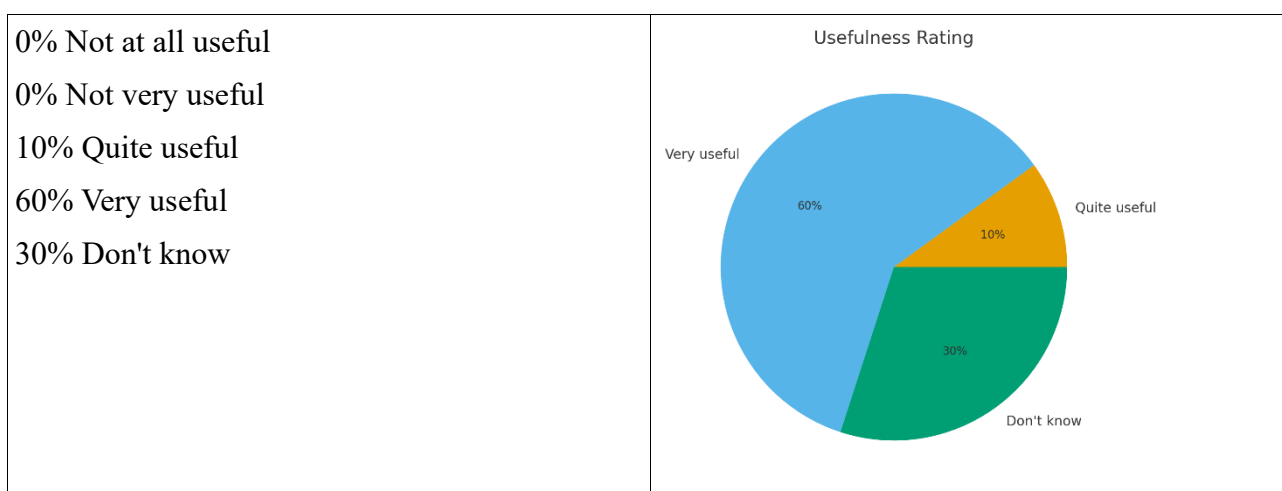
To the first question, “*How useful do you think an app dedicated to lifestyle change is?*”, the answers were:



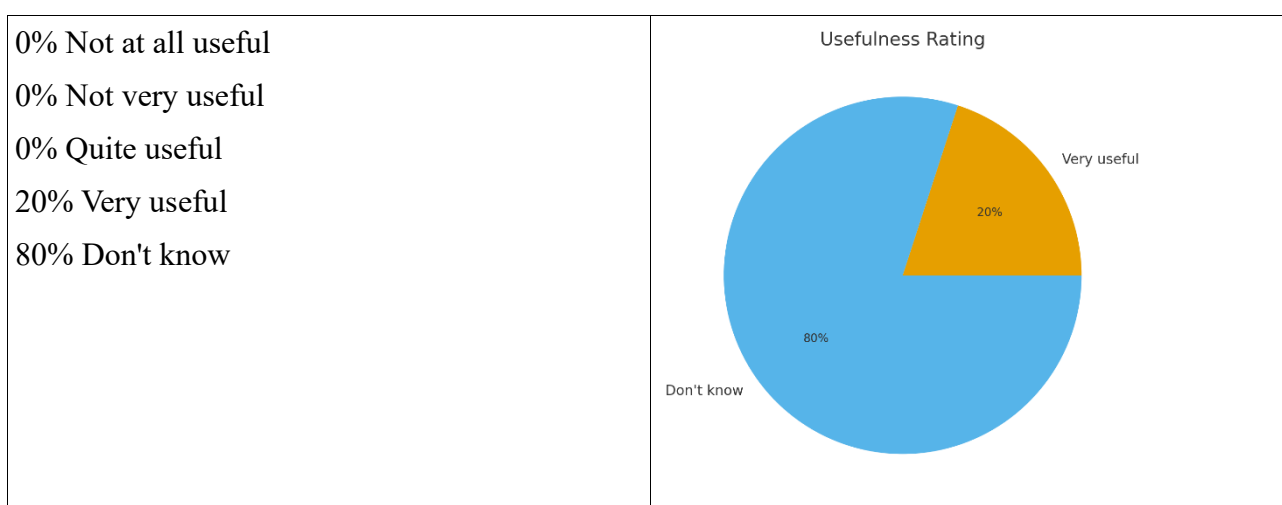
To the second question, “*How often do you measure your urinary or salivary pH?*”, the answers were:



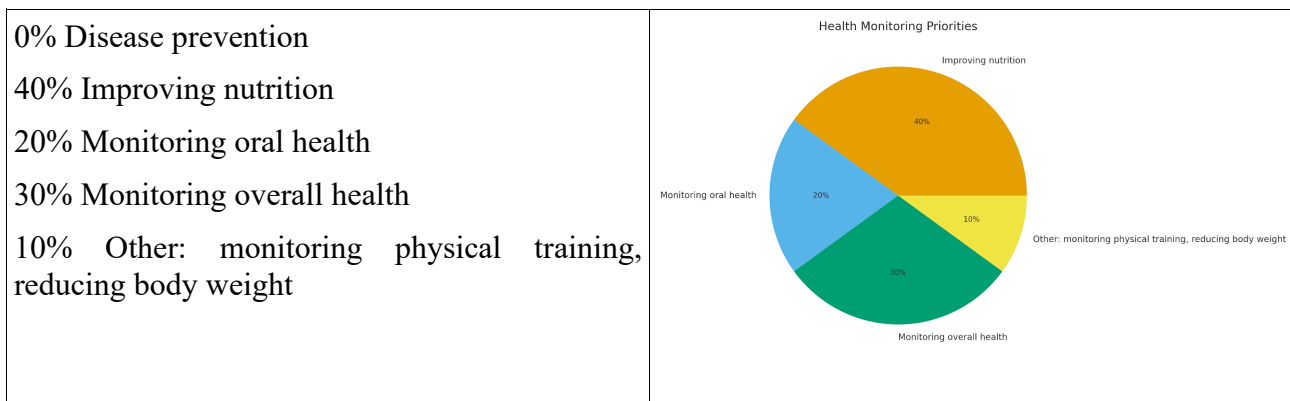
To the third question, “*How useful do you think pH monitoring is for your overall health?*”, the answers were:



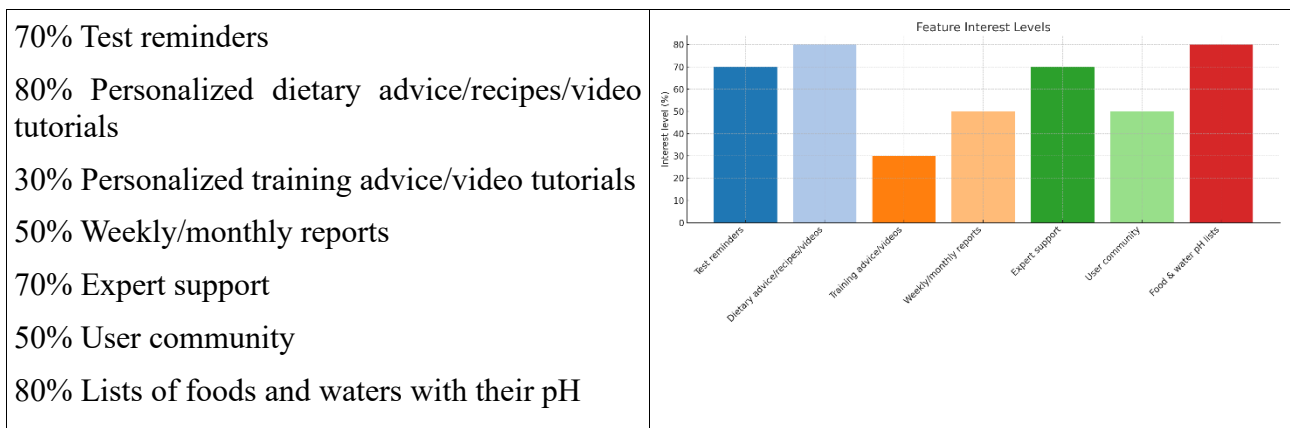
The responses to the fourth question, “*How useful do you think pH monitoring is for your oral health?*” were:



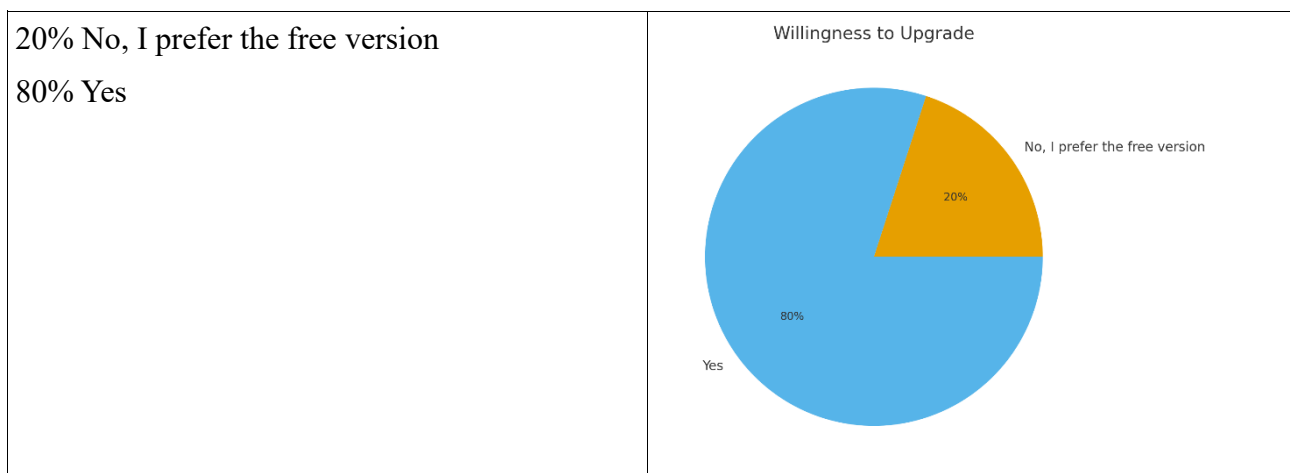
The responses to the fifth question, “*What reasons motivate you to use or want to use an app of this type?*” were:



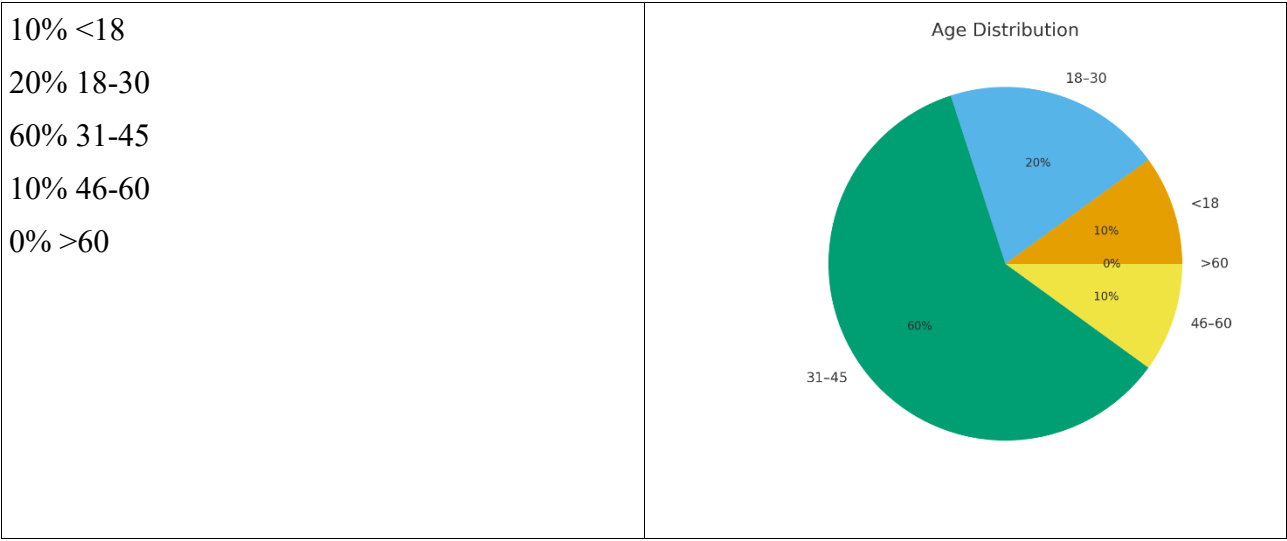
The sixth question, “*What features would you like to see in a pH monitoring app? (you can choose more than one)*” received the following responses:



The seventh question, “*Would you be willing to pay for a premium version of the app with advanced and personalized features (monitoring of your nutrition, hydration, breathing, physical activity, and oral health by a team of experts)?*” received the following responses:



To the eighth question, “*What is the most suitable age group for users of this app?*”, the answers were:



11. PREPARATORY ANALYSIS FOR APP DESIGN

In order to design this app in a serious and comprehensive manner, we carried out a number of analyses, which are outlined below.

11.1 SWOT Analysis

SWOT analysis is a strategic tool used to evaluate the strengths, weaknesses, opportunities, and threats of a project, product, or idea.

It is used to make informed decisions, set a strategy, and identify areas for improvement or development.

SWOT is an acronym for:

- **S – Strengths**
- What works well? What competitive advantages do you have?
- (e.g., proprietary technology, experienced team, low costs)
- **W – Weaknesses**
- What needs to be improved? What puts you at a disadvantage?
- (e.g., lack of experience, limited resources, low visibility)
- **O – Opportunities**
- What trends or external situations can you take advantage of?
- (e.g., new markets, emerging technologies, unmet needs)
- **T – Threats**
- What external risks could hinder you?
- (e.g., competition, regulatory changes, economic crises)

11.2 SWOT analysis for HpH App

1. Strengths

- *Innovative and personalized:* combines two types of measurement (urine and saliva) for a more complete view of health. The app is based on a simple but significant biological parameter (pH) to guide both general and oral well-being.
- *Concrete primary prevention:* educates and guides healthy users to maintain physiological balance. This approach is currently under-explored in the app world. Users are initially divided into healthy patients and patients with pathologies.
- *Comprehensive and scientific approach:* links pH to nutrition, exercise, hydration, immune system function, and oral health.
- *Objective data:* users can observe a direct link between behavior and physiological state. The ability to obtain data that reflects their behavior can encourage users to maintain healthy and preventive habits over time.
- *Structured frequency:* by requiring daily measurements, the app creates a solid routine (urine: morning/evening – saliva: morning/after meals/evening).
- *Educational potential* for doctors, dentists, hygienists, nutritionists, and physical therapists or athletic trainers.
- *Health education:* users learn to read their body's signals and react before pathologies emerge.
- *Low initial technical complexity:* MVP can be achieved quickly with essential functionality.
- *Versatility of use:* suitable for various user profiles (athletes, health enthusiasts, people at risk, etc.).

2. Weaknesses

- *Requires high compliance:* multiple measurements per day may discourage inconsistent users.
- *External measurement tools:* need for reliable test strips or accurate sensors. However, the tools chosen for this study are extremely inexpensive and do not exclude any segment of the population (HpH €2.89 vs. Withings U-Scan Nutrio €349.95/€429.96).
- *Understanding of results:* not all users understand the meaning of pH values. Graphs and explanatory tables must be provided so as not to alarm the patient and to guide them only in the consistency of changes in their lifestyle.
- *Not yet a medical standard:* pH is not universally considered a reliable marker in conventional medicine. It is certainly a good indicator of general health, but not sufficient to summarize the patient's overall health.
- *Risk of misinterpretation:* without guidance, the user could draw the wrong conclusions from the data. In this regard, the user must receive adequate information and advice to help them manage simple behaviors, without, however, replacing a thorough medical evaluation in cases where it is needed.
- *Measurement not always accurate:* Salivary/urinary pH can vary due to many factors not always related to health, so the patient must be informed of the correct measurement methods and the timing, which must be as repetitive as possible.

3. Opportunities

- *Growing trend towards wellness, health, and prevention.* New technologies can help fill the role that the national healthcare system should have developed in the context of primary prevention: monitoring healthy patients to prevent them from becoming ill. Apps such as HpH aim to do just that.
- *Integration with wearables and smart devices in the future (e.g., watches, sensors, etc.).* Smartphone use is now extremely widespread in Western societies and also globally. There are numerous apps that connect smartphones to watches or other types of sensors. Here too, a possible upgrade could be in this direction.
- *Possibility of building an active and loyal community around healthy lifestyles.* Being able to share improvements, exchange opinions, and be part of a group of users encourages each user to increase their use of the app.
- *Access to funds or calls for proposals for public health or digital preventive medicine.* As it could become a valuable tool for primary prevention, it is not out of the question that state or private entities could use it to promote primary prevention campaigns among the population.
- *Growing market for preventive and informed health:* the mHealth market is booming.
- *Integration with professionals (nutritionists, dentists, doctors, wellness coaches, etc.) to create hybrid services.* By providing tools that are useful for both oral hygiene management and the acquisition of balanced and healthy diets, this app can be a working tool for a variety of professionals.
- *Possibility of selling or integrating measurement kits (e-commerce associated with the app).* From a commercial point of view, the app can be integrated with dedicated pH measurement kits, digital pH sensors, or sensors for other parameters that can be evaluated from urine or saliva.
- *Oral health education targeting young people/adolescents or families.* Prevention in dentistry is simple and can be very effective if monitored over time: it is not enough to learn the best brushing and oral hygiene techniques if there is no significant change in daily diet and hydration.
- *Collaborations with dental practices for periodontal prevention.* In patients with periodontal

disease or alterations in oral bacterial flora, monitoring salivary pH is useful in managing diseases of the dental support system.

- *Opening up to the world of telemedicine and personalized coaching.* The creation of an app of this type gives patients a good degree of independence in becoming aware of how their lifestyle can disrupt their health balance but also allows healthcare professionals to monitor their patients remotely.

4. Threats

- *Indirect competition from more well-known generic health or diet apps (e.g., MyFitnessPal, Yazio).*
- *Health regulations to be complied with if entering the medical or diagnostic field.*
- *Rapid abandonment if the user does not perceive tangible results.* As with all apps that require continuous learning (e.g., Duolingo or Babbel for learning foreign languages, Yousician for learning to play musical instruments, etc.), this app also loses its meaning if not used consistently. There are apps for continuous blood glucose monitoring for diabetics, such as Dexcom ONE+, which allow patients to avoid hypoglycemic or hyperglycemic peaks and better manage insulin therapy. What is certainly difficult is making patients aware that in order to avoid diabetes, hypercholesterolemia, or other diseases, the effort must be made in the daily routine of normal meals. Patients aware that in order to avoid diabetes, hypercholesterolemia, or other diseases, they must make an effort in their daily lives to eat normal meals, exercise frequently and correctly, stay properly hydrated, breathe properly, and maintain their mental and physical well-being.
- *Criticism from conventional medicine regarding the use of pH as a generic indicator of health.*
- *Regulatory barriers (if entering the medical field).*
- *Dependence on external technologies for pH measurement that are not always reliable.* Litmus papers are a reliable, scientifically validated tool for providing an approximate, qualitative indication of pH, but they have limited scientific accuracy compared to more sophisticated alternatives such as digital pH meters. The papers offer limited resolution, usually in the order of one unit or half a unit of pH (e.g., pH 6, 7, 8). They cannot compete with a digital pH meter, which typically measures with an accuracy of 0.01 pH units. The pH value is determined by the pH of the solution in which the paper is immersed. (pH 6, 7, 8). They cannot compete with a digital pH meter, which typically measures with an accuracy of 0.01 pH units. The pH value is determined by visually comparing the color taken on the paper with a color reference scale on the packaging. This interpretation is subjective and can vary depending on lighting, the observer's color perception, and the presence of turbidity or color in the sample. On the other hand, they are extremely inexpensive, easy to use, and require no calibration or maintenance. They provide instant results, ideal for rapid testing in the field or in educational settings and are easy to transport and use anywhere.

11.3 VPC Analysis: Creating the Value Proposition Canvas

Value Proposition Canvas is a strategic tool used to precisely define the value that a product or service offers its customers. It serves to align what the creators of an app, in this case, are offering with what customers really need.

It consists of two main areas:

1. Customer Profile

Helps to understand the customer:

- *Jobs:* what the customer is trying to do (problems to solve, needs to satisfy).

- *Pains*: difficulties, frustrations, or obstacles they encounter.
- *Gains*: desired benefits, hoped-for positive outcomes.

2. Value Map

Describes how the product/service helps the customer:

- *Products & Services*: what you offer.
- *Pain Relievers*: how you alleviate the customer's problems.
- *Gain Creators*: how you generate the desired benefits.

The goal is to “match” the customer profile with the value proposition.

When the value offered responds well to the customer's needs, problems, and desires, we talk about product-market fit.

11.4 VPC Analysis for HpH

a. Customer Profile (user profile)

1. Jobs (Tasks to be performed)

- Monitor your oral and general health on a daily basis in a simple and accessible way.
- Prevent inflammatory and degenerative diseases through lifestyle changes.
- Receive objective data to guide food and behavioral choices.
- Keep oral health under control to avoid cavities and gum problems.
- Have constant and motivating feedback to maintain healthy habits.
- Feel autonomous and responsible for your own health.

2. Pains (Problems/Pains)

- Poor understanding of the body's signals.
- Difficulty in changing lifestyle without immediate feedback.
- Lack of simple, everyday tools for prevention.
- Confusion about which habits are truly healthy.
- Fear of disease, but passivity in preventing it.
- Desire to avoid high costs for check-ups or specialist consultations.

3. Gains (Desired benefits)

- Simple, objective, and inexpensive tool for health monitoring.
- Feeling of tangible physical improvement.
- Autonomy in managing well-being.
- Personalized health education.
- Active, daily, non-invasive prevention.
- Integration with a healthy lifestyle.

b. Value Map

1. Products & Services

- Mobile app for entering and tracking urinary/salivary pH.
- Graphs and trends of daily values.
- General/personalized nutrition tips: list of foods with pH and PRAL indices, food combination guidelines, recipes to encourage an alkaline-rich diet
- General/personalized hydration tips: list of waters with pH indices, recipes to encourage alkaline-rich hydration, reminders throughout the day to achieve adequate hydration based on body weight (connected to a smart water bottle, for example).
- General/personalized tips on breathing: breathing exercises to stimulate the reduction of a risk

factor for pH reduction, stress, and to stimulate proper gas exchange, video tutorials for performing dedicated workouts

- General/personalized suggestions on movement: list of aerobic exercises aimed at rebalancing the body's acid-base balance, reminders to encourage the user to engage in daily physical activity (e.g., connection to a smartwatch with a pedometer), video tutorials for performing dedicated workouts
- General/personalized tips on oral hygiene: timer for brushing, photographic monitoring of plaque with the aid of plaque-disclosing tablets, video tutorials for learning brushing techniques
- Integrated education on prevention, immunity, and oral health.
- Smart reminders.
- Notes area and health diary.
- Possible physical kit (maps, pH sensors).

2. Pain Relievers

- Provides objective data, creating less uncertainty.
- Encourages consistency with notifications and visual graphs.
- Bridges the gap between health and illness (true primary prevention).
- Reduces the need for frequent visits or tests.
- Makes healthy, repeatable habits easy.

3. Gain Creators

- Empowerment: the user becomes the protagonist of their own health.
- Visible results create positive reinforcement for lasting change.
- Promotes a consistent, non-punitive lifestyle.
- Facilitates the relationship between behavior and physical results.
- Increases body awareness and confidence.

11.5 BMC Analysis - Business Model Canvas

Another useful tool in app design is the BMC. The Business Model Canvas (BMC) is a visual and strategic tool designed by Alexander Osterwalder to describe, design, analyze, and innovate a business model in a clear, concise, and integrated way.

It is a map or framework divided into nine fundamental blocks, each of which represents a key element of how an organization creates, distributes, and captures value. The BMC allows entrepreneurs, managers, and startups to have an overview of their business, facilitating understanding of the internal and external dynamics that influence success.

It consists of the nine blocks of the Business Model Canvas:

1. Customer Segments: identifies the groups of people or organizations that the product or service is aimed at. Differentiating segments helps to define specific offers for each one.

2. Value Propositions: describes the products and services that create value for each customer segment, solving problems or satisfying specific needs.

3. Channels: indicates how the company reaches and communicates with customers to deliver the value proposition (sales, distribution, communication). There are three channels:

a. Communication: a simple tool to share with teams, investors, and stakeholders.

b. Innovation: helps discover opportunities for improvement and new models.

c. Validation: useful for testing hypotheses and understanding whether the model can work in the market.

4. *Customer Relationships*: explains the type of relationship the company establishes with each customer segment (personalized support, self-service, community, etc.).
5. *Revenue Streams*: specifies how the company earns from each segment (direct sales, subscriptions, licenses, advertising).
6. *Key Resources*: identifies the fundamental assets (physical, intellectual, human, financial) necessary to create and deliver the value proposition.
7. *Key Activities*: describes the most important activities for the business model to function (production, marketing, technological development, customer management).
8. *Key Partnerships*: lists the suppliers, strategic alliances, and collaborations necessary to carry out key activities or optimize resources.
9. *Cost Structure*: reports the most relevant costs for maintaining the business model (fixed costs, variable costs, investments in technology, personnel).

It is important because it provides a visual summary, putting the business structure on a single page, and because it is flexible: it facilitates rapid iterations and changes.

11.6 BMC analysis for HpH app

1. Customer Segments

- People who are health and wellness enthusiasts.
- Individuals who are healthy or have inflammatory/degenerative risks or conditions.
- Patients who are healthy or have oral problems (tooth decay, gingivitis).
- Athletes and active people.
- Health professionals (nutritionists, dentists).
- Wellness centers, clinics, gyms.

2. Value Propositions

- Simple, daily, economical, and objective monitoring of urinary and salivary pH.
- Personalized support to improve lifestyle and prevent disease.
- Health education based on concrete data.
- Primary prevention through self-management of health.
- Reduction in medical visits thanks to continuous monitoring.

3. Channels

- App stores (iOS and Android).
- Website and informative blog.
- Collaborations with medical practices, clinics, and wellness centers.
- Social media and online communities.
- Events, webinars, and workshops on prevention.

4. Customer Relationships

- Digital support (chat, FAQs, tutorials, advice, recipes).
- Wellness centers, gyms, clinics, dental practices.
- App distribution platforms (Apple Store, Google Play).
- Health prevention associations and organizations.
- Personalized notifications and reminders.
- Community for sharing experiences.
- Coaching programs and premium subscriptions.
- Continuous feedback and user-based updates.

5. Revenue Streams

- Freemium model with free basic features and paid premium features: the freemium model is free and provides guidance to people in good health. If the user has health issues, it is useful to have a more personalized profile and a doctor who can be in contact with the user. The personalization and management of the doctor/user relationship should be paid for, to cover the costs of medical consultation.
- Monthly/annual subscriptions for personalized content and consultations.
- Sale of physical pH test kits (strips, sensors).
- Partnerships with professionals and companies in the health sector.
- Targeted sponsorships in the wellness sector.

6. Key Resources

- Software development team and UX/UI designers.
- Experts in nutrition, preventive medicine, and dentistry.
- Secure database and IT infrastructure.
- Production and procurement of materials for pH kits.
- Marketing channels and collaboration networks.

7. Key Activities

- Development and continuous updating of the app.
- Scientific research and data validation.
- Production and distribution of pH kits.
- Digital marketing and community management.
- Customer support and personalized coaching.

8. Key Partnerships

- Suppliers of pH test materials.
- Health professionals (doctors, dentists, nutritionists).

9. Cost Structure

- App development and maintenance costs.
- Expenses for scientific research and validation.
- Marketing and user acquisition.
- Technical support and customer care.
- Production and logistics of pH kits (if included).

11.7 Design of an MVP (Minimum Viable Product)

Based on the analyses carried out and the results obtained, we proceeded with the design of an MVP.

An MVP is a version of a new product that has only the essential (minimum) features necessary to meet two main objectives: to attract early adopters, people willing to try the product right away, and to receive validated feedback in order to learn from the actual use of the product by users.

The main objective of the MVP is not to launch a finished product, but to validate a hypothesis or idea in the shortest possible time.

An MVP for an app dedicated to monitoring body and saliva pH must be simple but functional, with a focus on usability and user data collection.

1. App objective

To provide a tool for recording, viewing, and tracking body pH (saliva and/or urine) over time, offering general suggestions related to lifestyle, diet, and physical activity.

2. Core features

a. Dashboard

- Display of the last value entered (pH)
- Brief indication: “Acidic,” “Neutral,” “Alkaline”

b. Manual data entry

- Date and time
- Type of measurement: saliva/urine
- pH value (e.g., 6.2)
- Optional notes

c. History and graphs

- Calendar with measurements
- Timeline graph (weekly/monthly/annual trend)

d. Notifications

- Reminder 1-2 times a day to enter pH

e. General (static) advice

- Alkalizing diet
- Hydration
- Breathing techniques
- Physical exercise
- Oral hygiene

3. Suggested technology stack

3.1 Frontend (cross-platform):

- Flutter (Dart) → Modern UI, rapid development for iOS/Android

3.2 Backend:

- No backend: local data storage (e.g., SQLite or Hive)
- Firebase (Realtime DB or Firestore) if cloud storage

3.3 Analytics:

- Firebase Analytics (minimum user tracking)

4. Future extensions (not MVP)

- Integration with pH sensors (via Bluetooth)
- Personalized dietary suggestions
- Machine learning for predictions and correlations
- Data export (PDF/CSV)
- Community or forum

5. Simple UI/UX (low-fidelity wireframe)

The chosen interface is minimal and schematic, without complex graphics. It is used to test logic and usability.

a. Home

Shows the current pH value entered by the user (e.g., “pH 6.8”). It includes a simple graph (e.g., line or bar) showing the trend over the last few days. It has a “+” button to add new data.

b. New Data

When you click on “+”, a screen opens where the user can select the pH by tapping the color of the pH wheel corresponding to the one detected on the paper used for the evaluation.

If you want, you can activate the camera, which detects the pH color gradation on the litmus paper and automatically enters it into the app.

If the camera is selected, the application automatically launches the rear camera of the device so that the user can take a photograph of the pH detection litmus paper. After selecting or taking the photograph, automatic image processing starts automatically. This processing involves the use of the circular Hough transform (CHT) to detect the circular colorimetric sensor.

CHT is a feature extraction technique used in digital image processing to identify circular objects in imperfect digital images (Kimme C et al, 1975). Before CHT detects the circle, a preprocessing step is required to prepare the image. First, the image is denoised and then converted to grayscale, as subsequent functions require a grayscale image as input. After performing these operations, a low-pass blur filter smooths the edges and removes noise from the image. Finally, OpenCV's CHT function was used to automatically detect the pH sensor.

Upon detection, a separate mask is applied, which removes everything from the image except the detected circle. When creating each mask, the radius of the circle is reduced by 20% to ensure that the color of the sensor is detected entirely within the circle if the edges are blurred. After image processing, the application provides information about the detected pH sensor, including its average RGB and HSV coordinates.

Next, the pH value is calculated based on the corresponding calibration curve. At the end of the entire processing pipeline, the app generates a text report, which is saved to the phone's memory, containing all the information collected on the detected pH sensor.

c. History

Here is the list of data entered, e.g., “3 sets: pH 6.7.” It includes a line graph showing the evolution of pH over time. There is a weekly, monthly, and yearly history.

The graph highlights the correct pH, acidic pH, and alkaline pH limits, which differ for urine and saliva.

d. Profile

This is a section with optional user information: age, gender, height, weight, general health, type of diet, type of physical activity performed, etc.

This is useful for a variety of reasons:

In the case of healthy patients who are not undergoing drug therapy, the app will provide general guidelines for the various areas covered:

a. Nutrition: if the patient is omnivorous, vegetarian, or vegan, appropriate recipes will be recommended to best manage the acid-base balance in the body. Using height and weight data, BMI can be calculated and more specific recommendations can be provided.

b. Hydration: based on body weight calculations, recommendations will be given on the approximate amount of water to be consumed daily, and recipes for vegetable juice extracts will be provided to help stimulate alkalization of the body (if, of course, the pH is found to be excessively acidic).

c. Breathing: in the case of acidic urinary pH, breathing exercises will be suggested (diaphragmatic

breathing, pursed-lip breathing, temporary increase in respiratory rate, etc.), including video tutorials to guide the patient through the exercises.

d. Physical activity: sequences of general and specific exercises are proposed that mainly energize the rib cage to improve the patient's ventilatory capacity, including video tutorials that guide the patient through the exercises.

6. MVP Roadmap

Between October 2024 and August 2025, the app was designed in three phases:

Phase 1: UI (User Interface) design, stack selection, project setup

Phase 2: Data input + saving + graphs

Phase 3: Reminders + suggestions + testing + Android/iOS build

Phase 1: UI design, stack selection, project setup

- *UI design:* the main screens (wireframes) are designed, deciding how the interface will look and function.
- *Technology stack selection:* languages are selected (Dart, used by Flutter; JavaScript/TypeScript, used by React Native; Kotlin/Java, for native Android; Swift, for native iOS), frameworks (tools that simplify and speed up app creation: with Flutter, you write once in Dart, it works on iOS/Android; React Native you write in JavaScript, compatible with multiple platforms and tools), backend and services (used to save data, manage users, send notifications, etc. For example, Firebase offers databases, authentication, push notifications; Supabase, Node.js + MongoDB, etc.) and other tools (Figma for UI design; Crashlytics, Sentry for monitoring bugs; Postman, for testing APIs).
- *Project setup:* create the initial structure of the project (frontend: create the project in Flutter, React Native, etc. and organize folders, e.g. /screens, /widgets, /services; backend: configure Firebase, or create a server with Node.js, database, API), configure development environments (install the necessary tools, e.g. IDE VS Code, emulators, SDK - development kit -, set up environment variables, permissions, certificates, etc.) and repositories (create a Git repository to save and manage the source code). This allows for versioning - change history - and team collaboration, e.g. git clone, git push, pull request.

Phase 2: Data input + saving + graphs

- *Data input:* Develop the functionality to enter pH values using the slider.
- *Saving:* The entered data is saved (e.g., locally or on Firebase).
- *Graphs:* A simple graph (e.g., line graph) is created to visualize the pH trend over time.

Phase 3: Reminders + suggestions + testing + Android/iOS build

- *Reminders:* Implementation of notifications (e.g., “Enter your evening pH”).
- *Tips:* Show personalized tips based on the data entered (e.g., “pH too acidic? Drink more water”).
- *Testing:* Test the basic functionality of the app (unit tests and manual tests) to identify bugs, logical errors, or usability issues before release. Testing ensures that even an MVP version is reliable and functional.
- *Build Android/iOS:* compile the app for publication or testing on real devices (.apk/.aab file for Android, Xcode/TestFlight for iOS).

12. DESIGN (UX/UI DESIGN) WIREFRAME

The HumanpH interface design was born with the goal of making the user experience simple, fluid, and highly intuitive, despite it being an app dedicated to monitoring scientific parameters such as urinary and salivary pH.

The app is aimed at a modern audience, accustomed to the daily use of technology and interested in their psychological and physical well-being. After a clear and welcoming welcome page, users access an introductory screen that illustrates the main features and explains how to best use the app in synergy with physical measuring devices.

HumanpH is, in fact, a phygital experience, capable of connecting the digital world with the real world: technology integrates with everyday life to offer continuous and conscious monitoring of one's body values.

The wireframe was conceived with usability and clarity in mind.

At the top of the interface are the app icon, which also provides quick access to general information and the introduction, and the navigation buttons for returning to the home page and the user profile, always available on every screen.

The personal profile allows you to view the history of recorded values (salivary and urinary), accompanied by trend graphs and personalized suggestions for improving your physiological balance.

In the footer, a system of contextual links guides the user to in-depth information and educational content relevant to the area of the app they are in.

The interface, designed for accessibility, readability, and visual comfort, was created with Adobe XD, the ideal tool for prototyping and testing the interactive experience before development.

Logo and Colors

The Human pH logo is born from the harmonious union between humanity and science. The acronym "Human pH" represents the balance between body and environment, while the letter "P" becomes a dynamic symbol: a visual indicator that changes color to instantly represent the user's level of well-being, whether positive or negative.

The color palette echoes the tones of litmus paper, translating scientificity into visual emotion: from yellow and green, expressing balance and health, to orange and dark red, indicating imbalances requiring monitoring.

The visual identity and interface work synergistically to communicate trust, clarity, and immediacy: three key values for an app that aims to guide users on a daily journey of awareness and prevention.

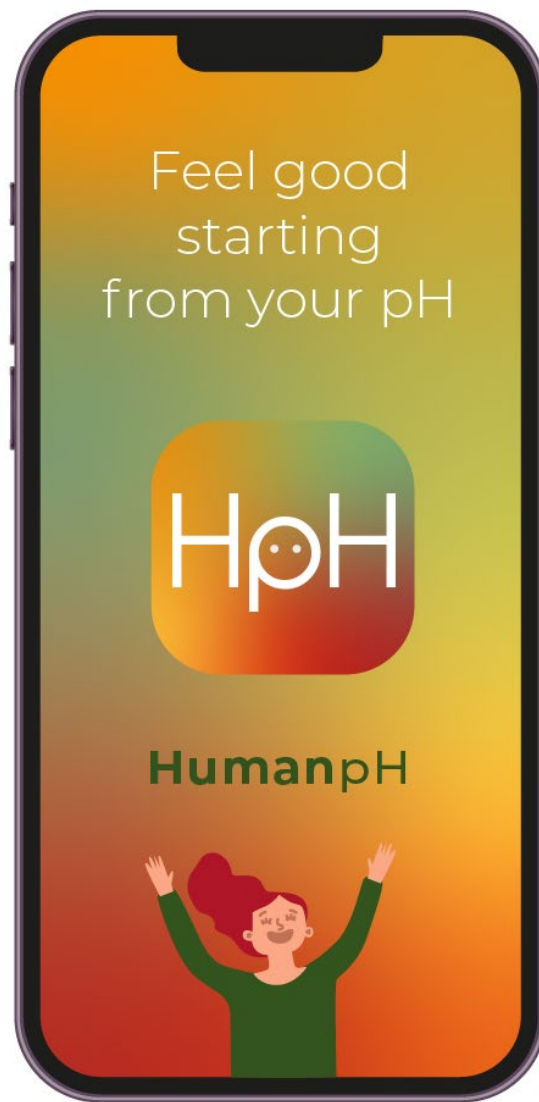


Figure 4. Welcome Page: The logo uses the colors of a litmus paper palette. The "p" is a face that will be used in other contexts to indicate whether the pH is balanced or not. The image of a happy woman at the bottom highlights the centrality of the logo and allows for an emotional association between the woman's lightheartedness and happiness and the positivity the app can generate in terms of improving one's health.

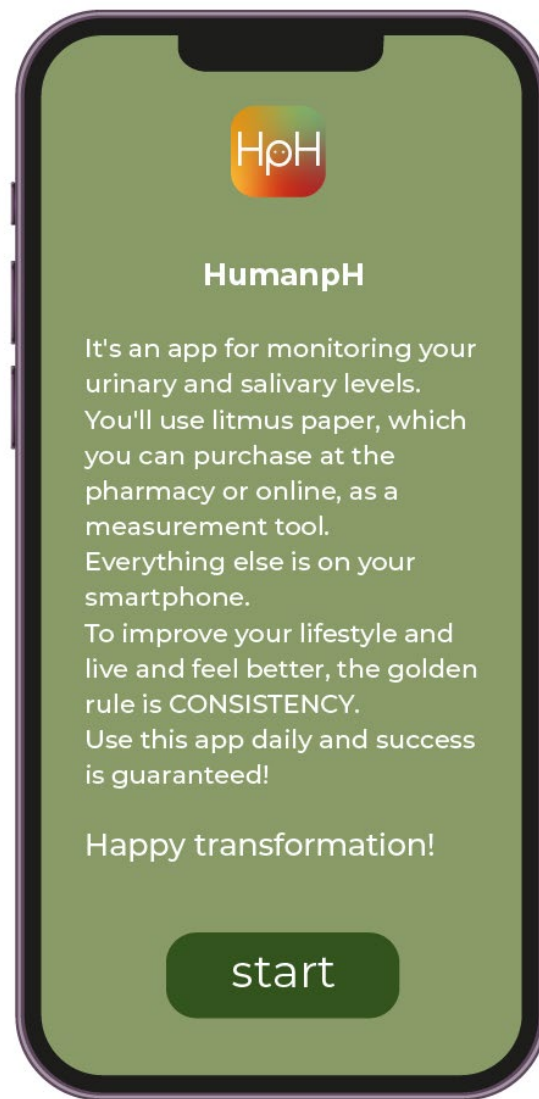


Figure 5. Introduction: a brief introduction explains to the user the tools that will be provided and the essential element of using the app, that is, consistency in its use.

HpH

Profile

Name

Date of birth

Sex ☐ M ☐ F ☐ OTHER

Height Weight

Do you have a sedentary job? ☐ Y ☐ N

General health condition

☐ Good no drugs ☐ Not Good ☐ Not good taking drugs

save

Figure 6. User profile: Users are invited to register and enter their name or nickname to join a community of users. Profiling is important because the presence or absence of medical conditions or medication intake directs users to enter a personalized profile, where they can be followed and monitored by a team of experts (doctor, dentist, nutritionist, physiotherapist, athletic trainer).

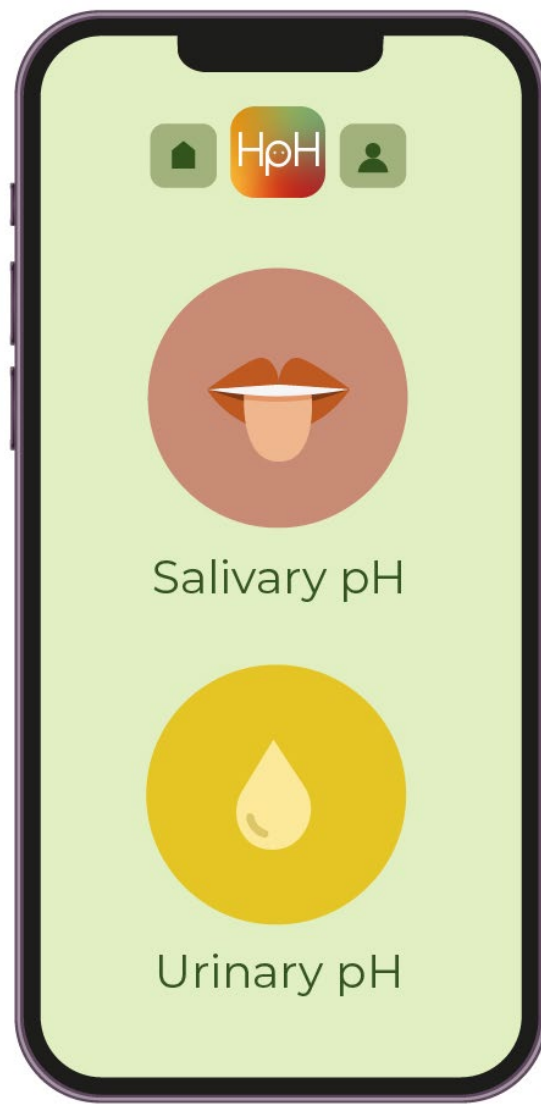


Figure 7. Measurement selection: Using two very simple and intuitive logos, users choose the type of measurement they wish to perform. The logos reflect the colors of the oral mucosa (red) and urine (yellow).

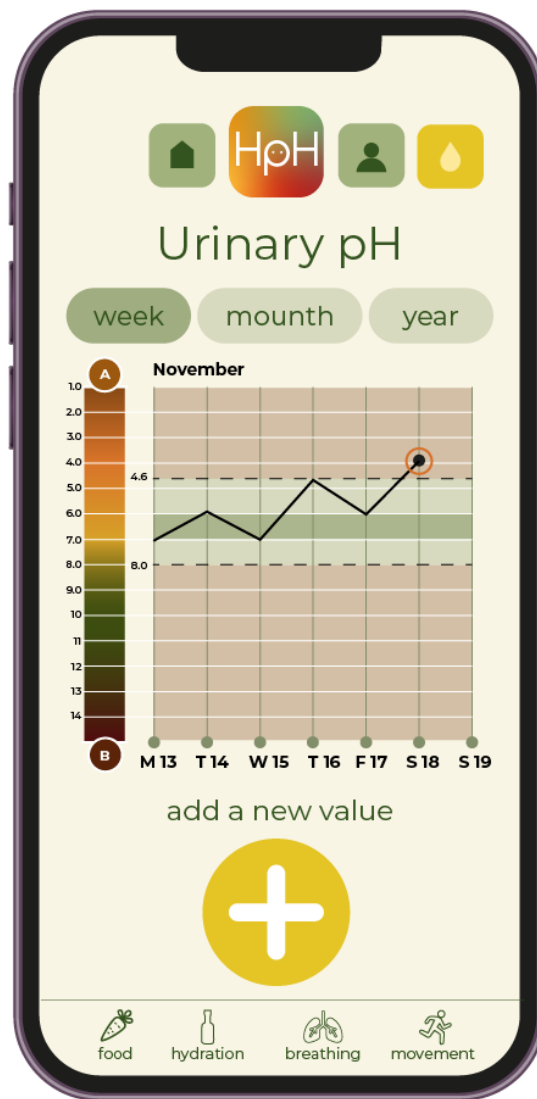


Figure 8. Once the "Urinary pH measurement" option is selected, a screen opens where you can view the trend of your pH measurements over the course of the week, the current month, and the current year. A graph visually highlights the optimal values for a urinary pH between 6.0 and 7.0, acceptable values for a pH between 4.6 and 8, and critical values for values below or above this range. A "+" button allows the patient to enter a new measurement.

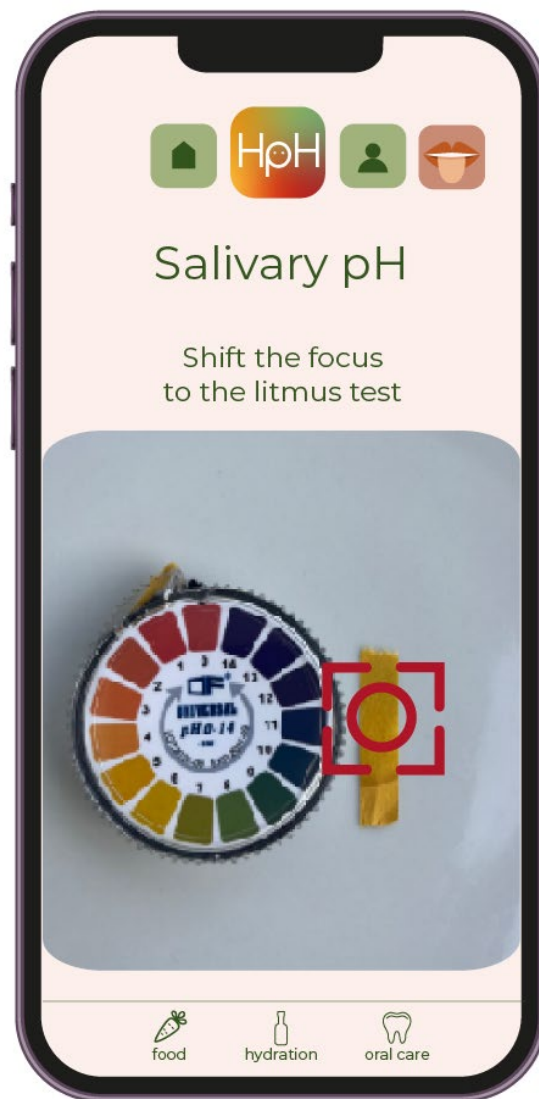


Figure 9. The user takes the measurement by placing a drop of urine on the litmus paper. The camera activates automatically, and a cursor detects a pointer circle to capture the correct color of the wet paper. The photograph must be taken with a flash to ensure repeatability of the assessment even in situations with different ambient lighting.

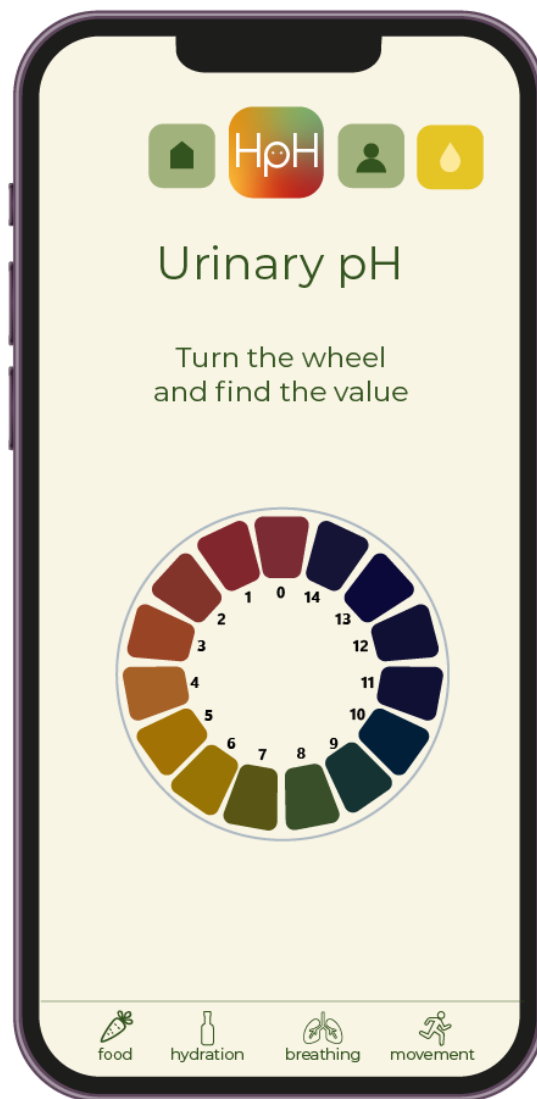


Figure 10. Alternatively, if the camera isn't available, users can enter the detected value themselves by comparing the color acquired from the wet litmus paper with the color scale provided by the litmus paper manufacturer. By sliding their finger along the color wheel, users determine the color correspondence between the paper and the color on the color scale.

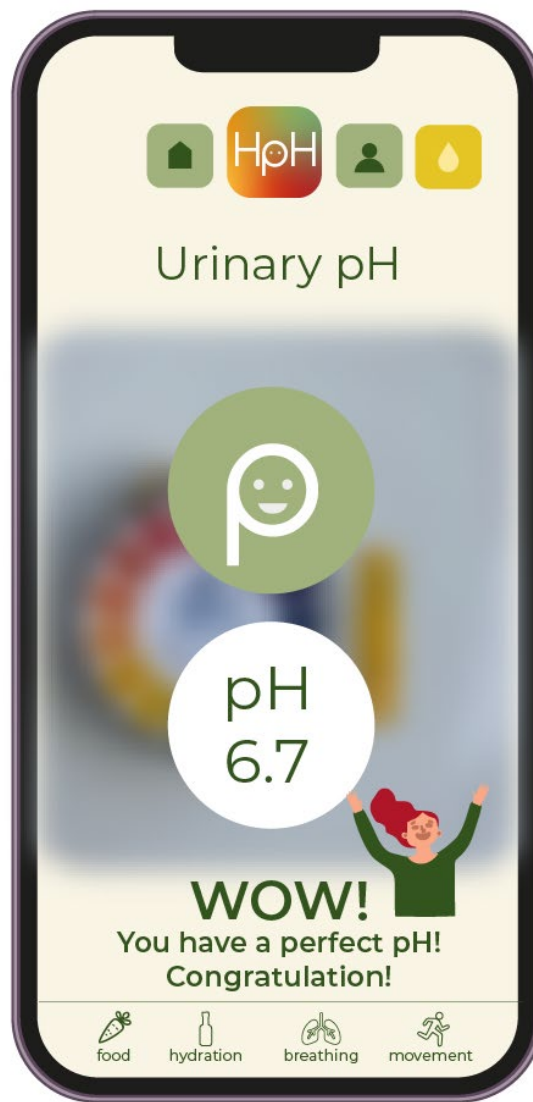


Figure 11. If the value obtained is correct and optimal, the data is communicated with the association of an image that conveys positivity and success: the face of the “p” is smiling, the colors correspond to the optimal pH value to be obtained, the patient receives congratulations, and the data is automatically inserted into the pH values graph.

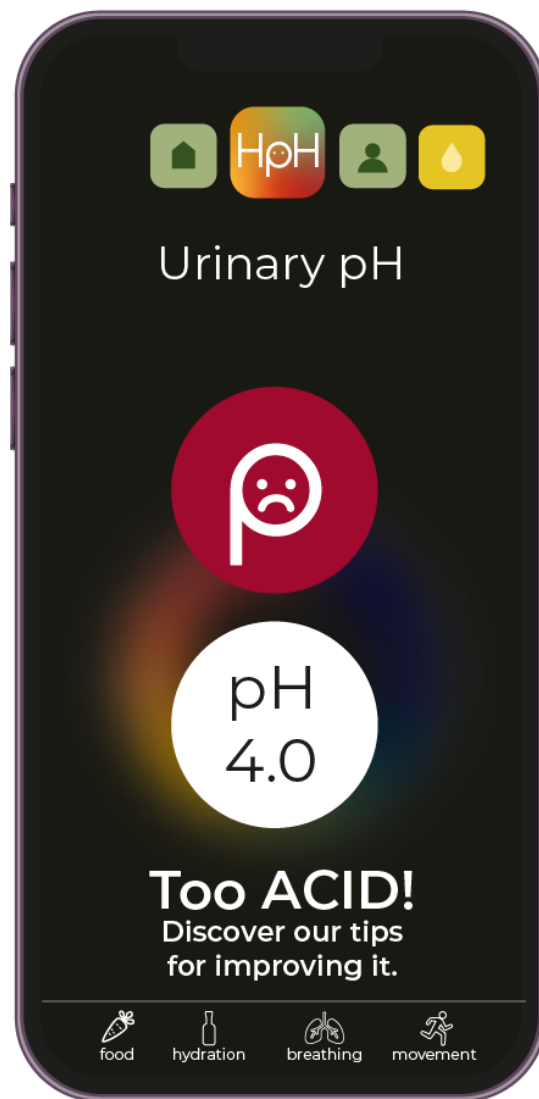


Figure 12. *If the pH is outside the normal range, the face of the "p" becomes sad, the color turns red (a typical alarm color), and the patient is advised to consult programs to improve pH, such as nutrition, hydration, breathing, and exercise. Until a pH measurement brings the pH back within physiological values, users will receive reminders encouraging hydration, exercise, etc.*

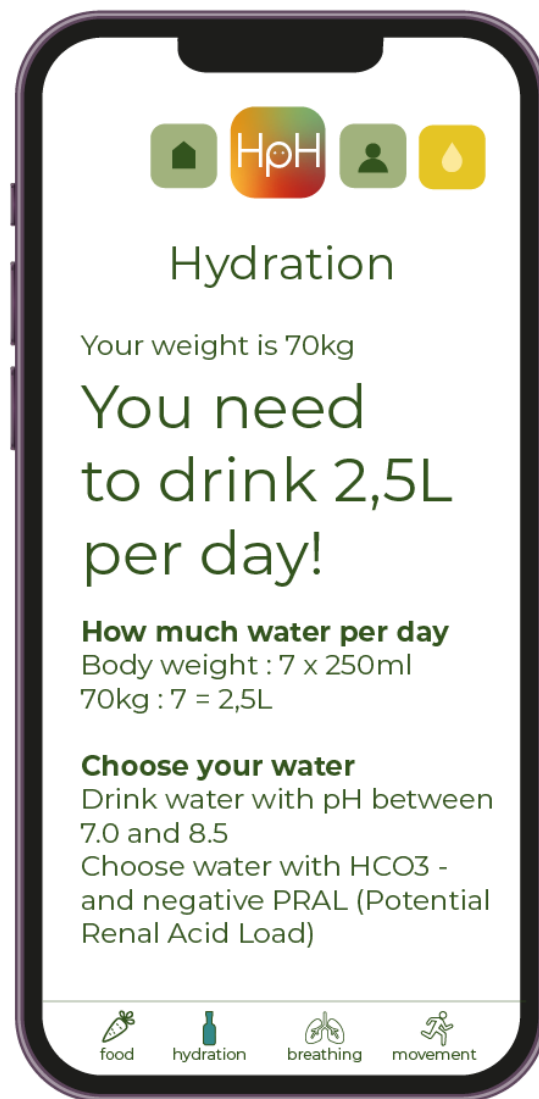


Figure 13. If the pH is incorrect, the app begins to encourage users to make changes in their behavior. Users can then decide whether to receive messages or notifications for all four areas (nutrition, hydration, breathing, and movement) or choose to receive messages or notifications only for those areas where they feel lacking (e.g., users already drink enough water daily but do too little physical activity).

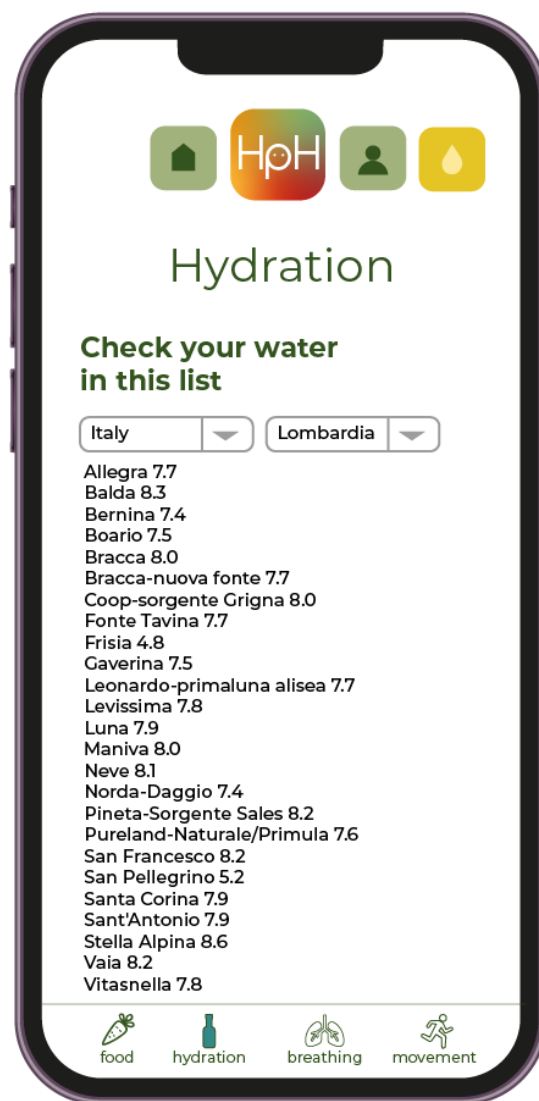


Figure 14. To facilitate the choice of the most appropriate alkaline water, users are provided with an updated list of the main oligomineral waters present in his country and divided by geographical area.

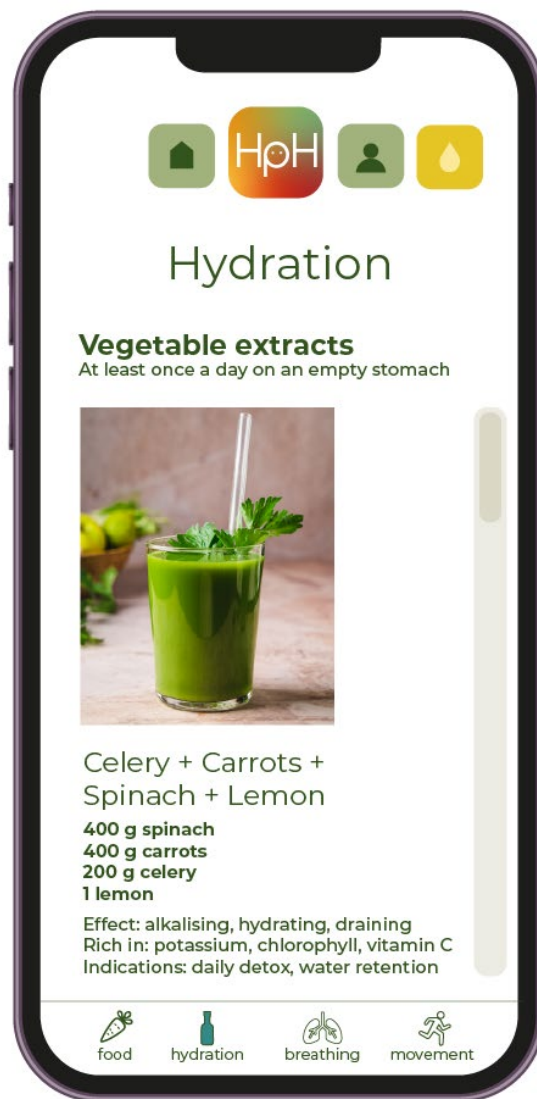


Figure 15. Recipes for vegetable juice extracts are also provided to allow healthy alternatives to water and to distance the patient from the use of sugary carbonated drinks, acidifying and sweetened fruit juices, and alcohol-based products which are also acidifying.

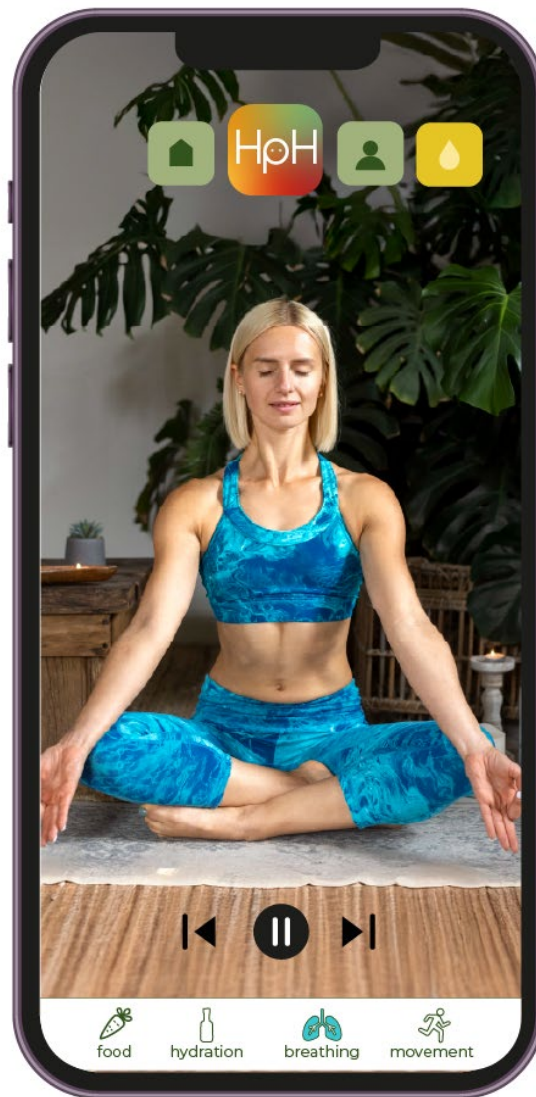


Figure 16. Users have the possibility of accessing video tutorials to learn and be guided through breathing exercises and guided meditation sessions for stress reduction (also an important factor in lowering the body's pH)



Figure 17. Users have access to numerous workouts and exercise videos to avoid a sedentary lifestyle and stimulate pH reduction through movement. If a customized program is needed, they can access personalized workouts or an online lesson directly with a physiotherapist or a personal trainer.

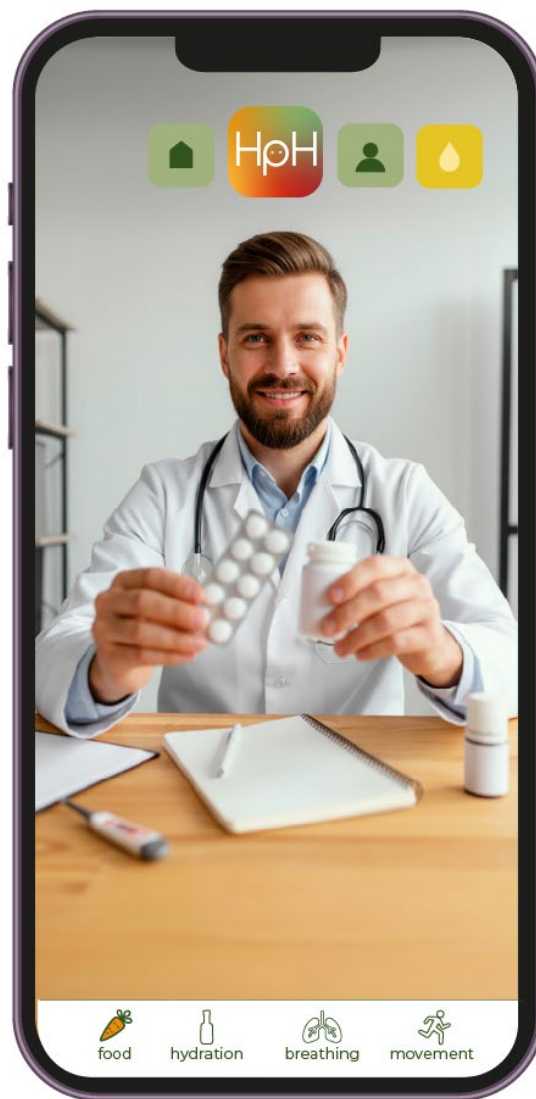


Figure 18. In the personalized profile, it is possible to be visited or receive online consultations from a member of the technical staff, in case a personalized nutritional profile is needed or the user suffers from pathologies that require a thorough evaluation before erroneously changing their lifestyle.

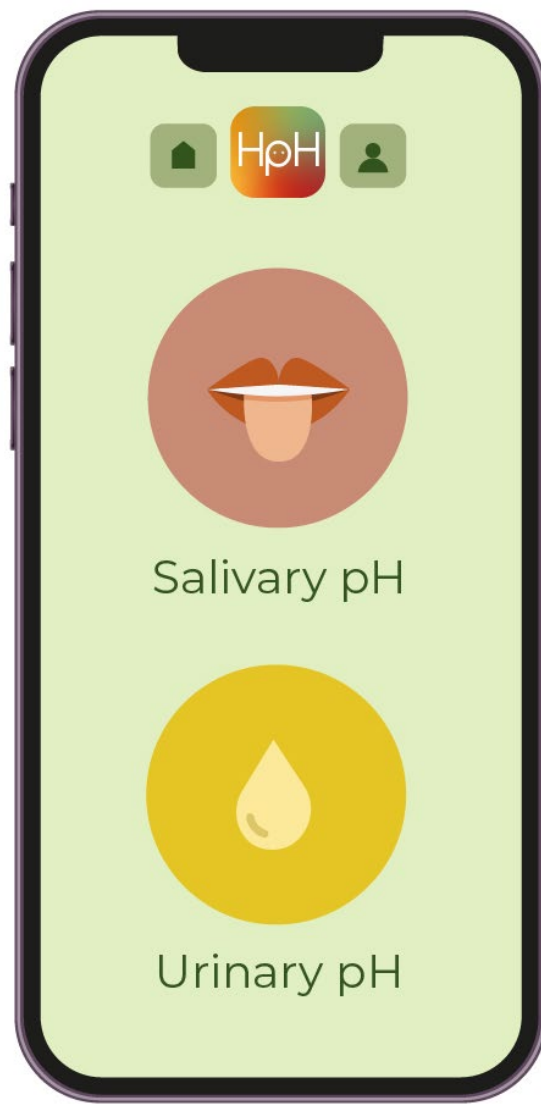


Figure 19. Users can then choose to evaluate salivary pH, for monitoring oral health.

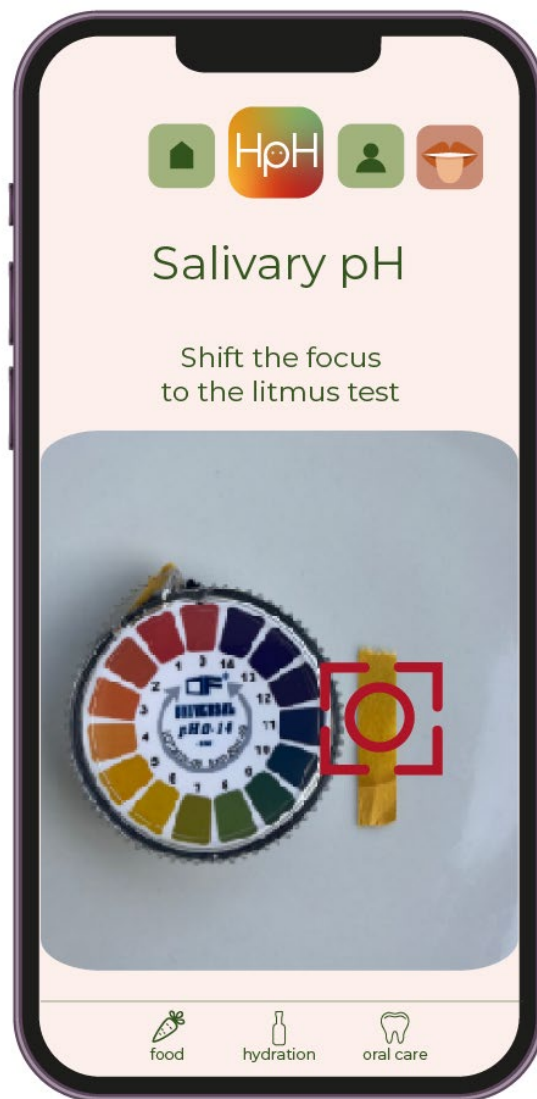


Figure 20. Users take the measurement by placing a drop of saliva on the litmus paper. The camera activates automatically, and a cursor detects a pointer circle to capture the correct color of the wet paper. The photograph must be taken with a flash to ensure repeatability of the assessment even in situations with different ambient lighting.

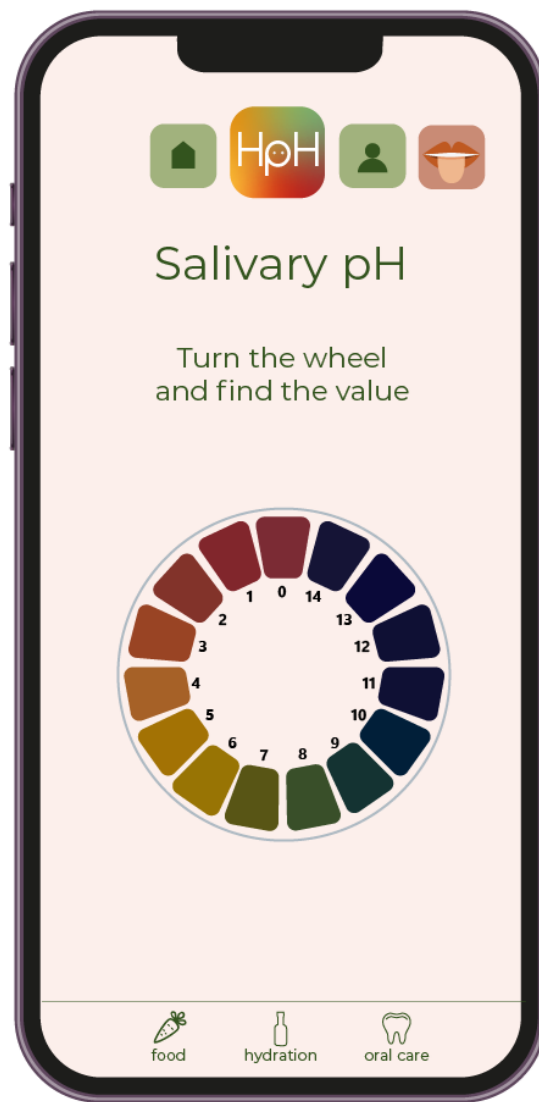


Figure 21. Alternatively, if the camera isn't available, users can enter the detected value themselves by comparing the color acquired from the wet litmus paper with the color scale provided by the litmus paper manufacturer. By sliding their finger along the color wheel, users determine the color correspondence between the paper and the color on the color scale.

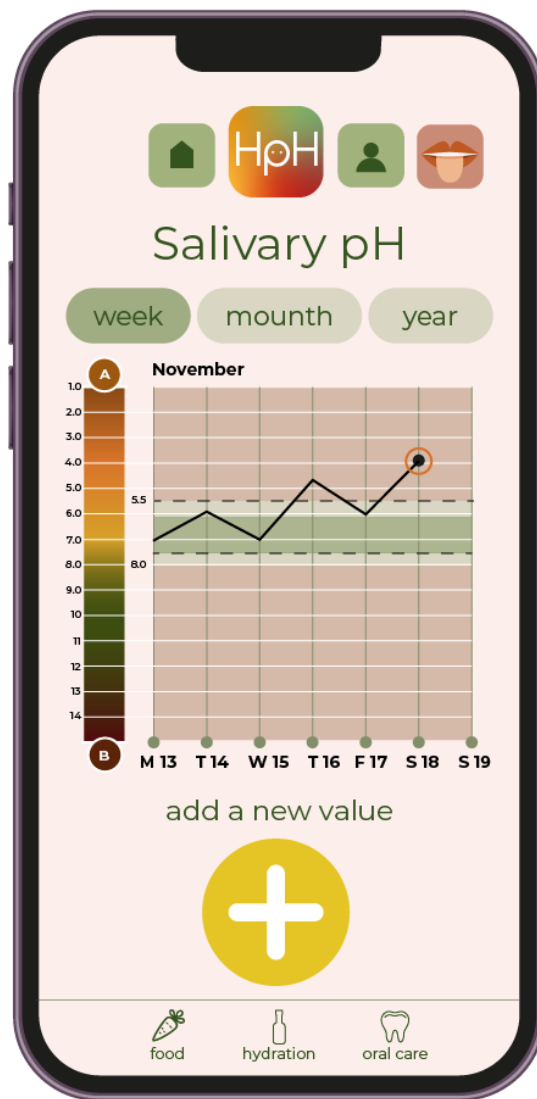


Figure 22. Once the "Salivary pH measurement" option is selected, a screen opens where you can view the trend of your pH measurements over the course of the week, the current month, and the current year. A graph visually highlights the optimal values for a salivary pH between 6.0 and 7.6, acceptable values for a pH between 5.5 and 8, and critical values for values below or above this range. A "+" button allows the patient to enter a new measurement.

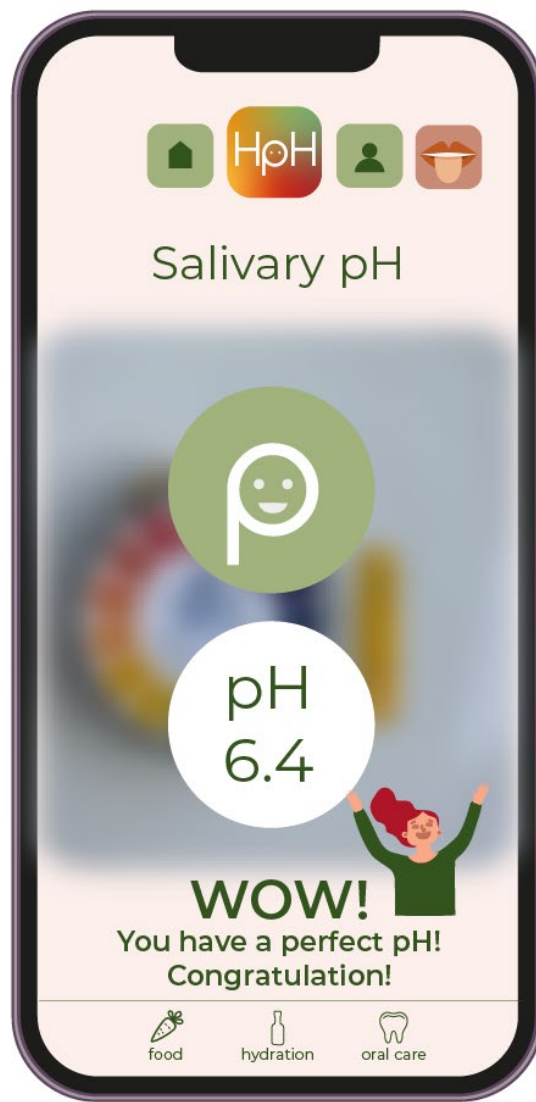


Figure 23. If the pH is optimal, between 6 and 7.6, the patient receives compliments from the application and his data is shared with the community to reward the patient's virtuous behavior.

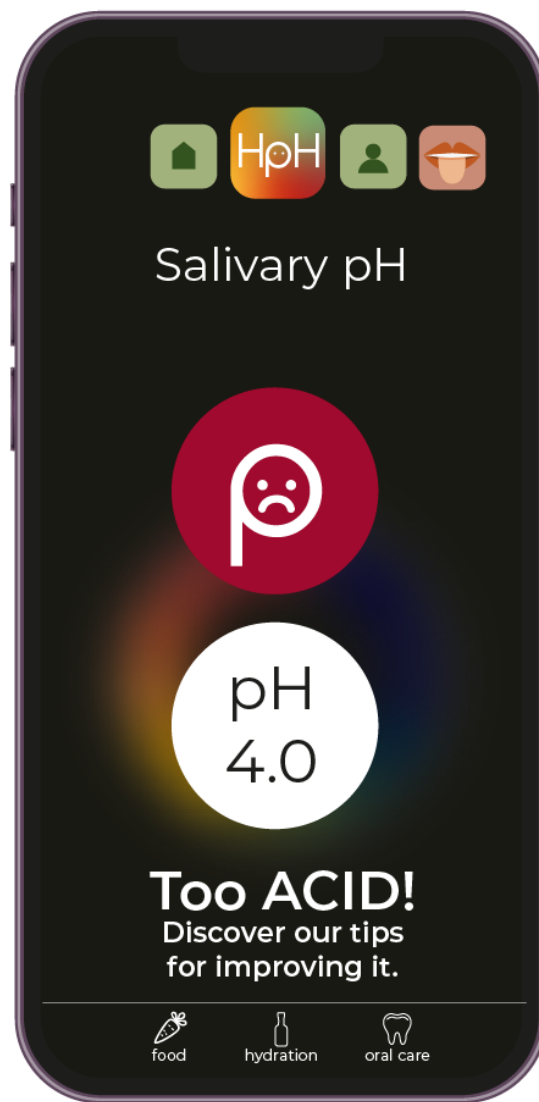


Figure 24. If the pH is below the correct threshold values, the patient is informed of the value on a red background (alarm) and will begin to receive reminders and stimuli for improvement.

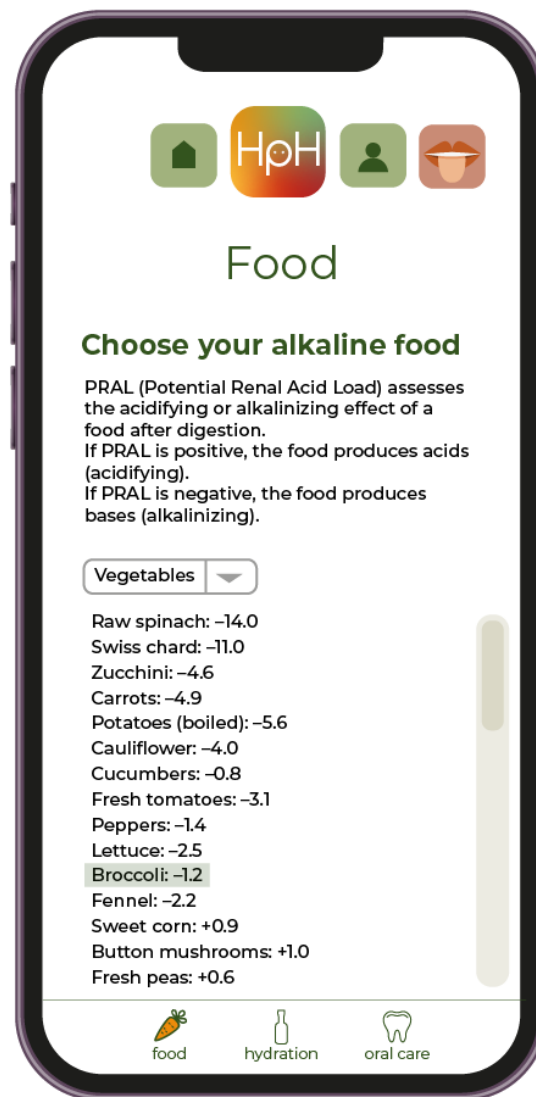


Figure 25. Users are provided with lists of foods with associated PRAL (Potential Renal Acid Load) values to increase knowledge and enable them to make more critical and careful choices when purchasing food products.

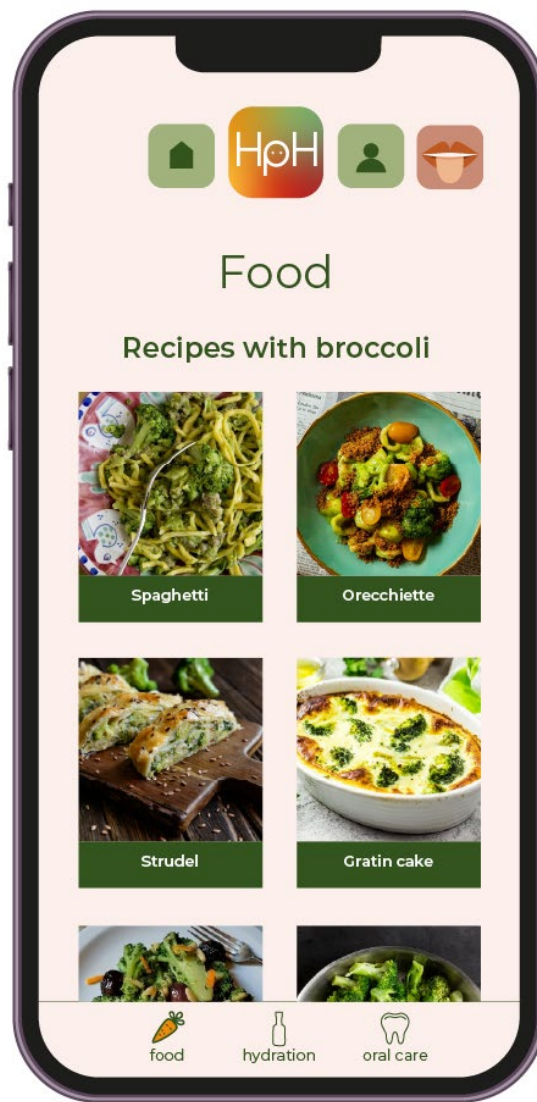


Figure 26. Users have access to numerous recipes featuring the correct food combinations, the presence of alkalizing products, and video tutorials to learn new ways of cooking and gradually modify their diet. The recipes can be printed via Bluetooth printer.

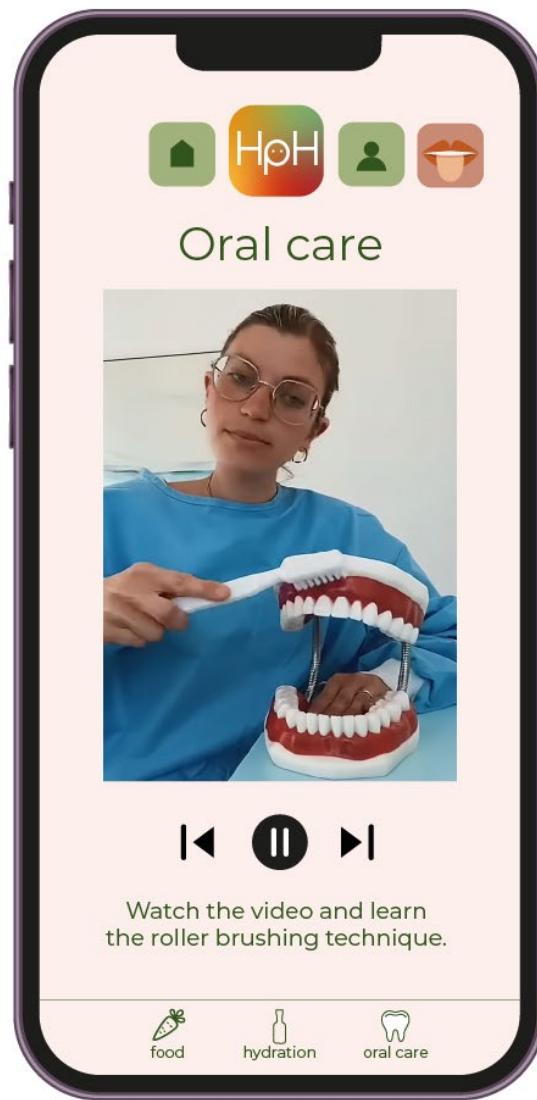


Figure 27. Users can both watch videos explaining correct brushing techniques and connect online with the professional for personalized instructions.

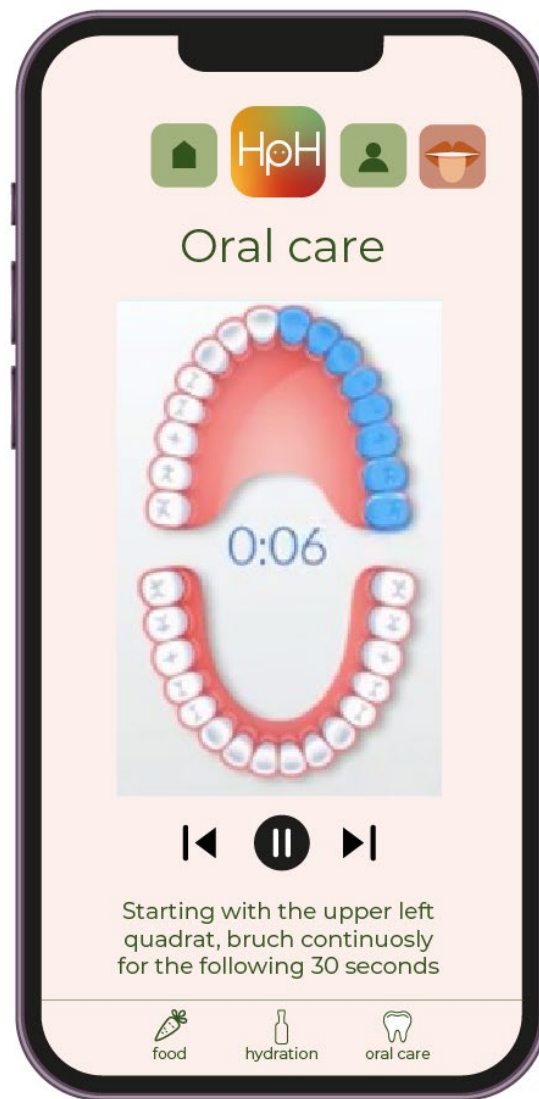


Figure 28. Timers are provided to encourage users to perform thorough oral hygiene, preventing excessively limited (and therefore ineffective) brushing time

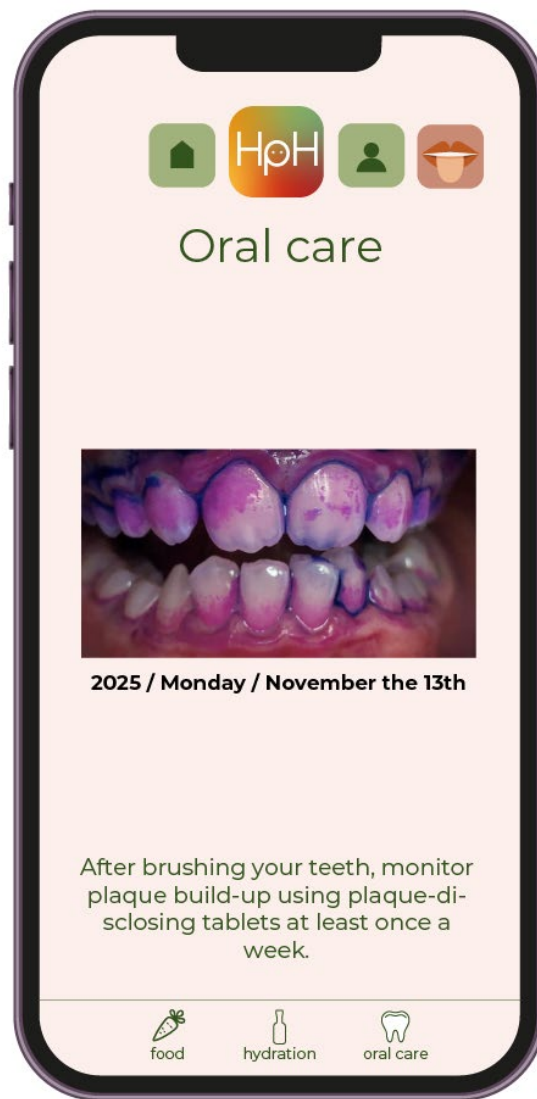


Figure 29. Users can monitor the amount of plaque using plaque disclosing tablets, to prevent plaque buildup by keeping the pH below 5.5.

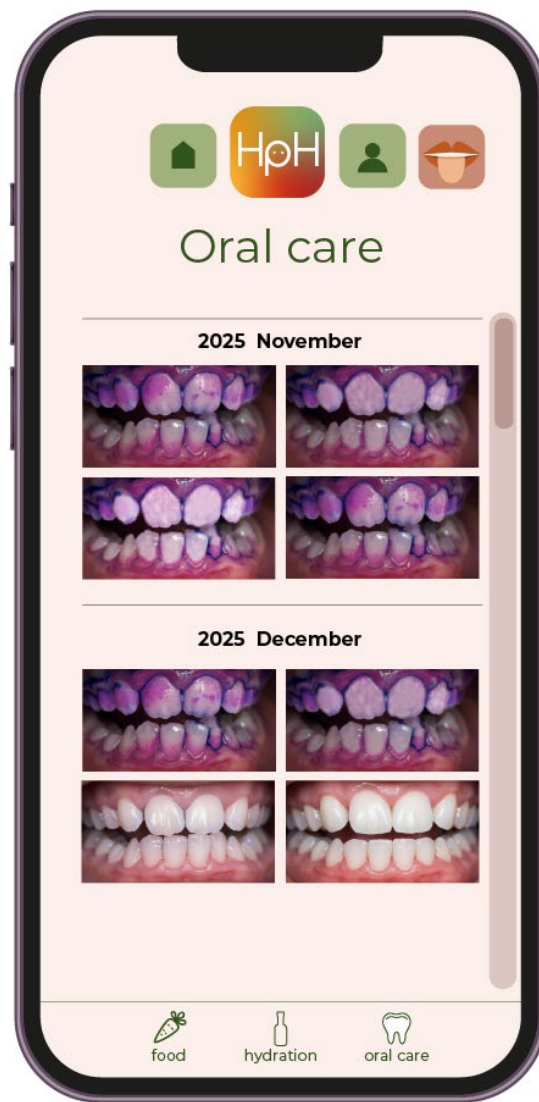


Figure 30. Users can monitor their oral hygiene status over time by comparing weekly photos. This data can also be shared with the dentist for feedback and to determine whether the patient has understood and correctly learned the instructions provided.

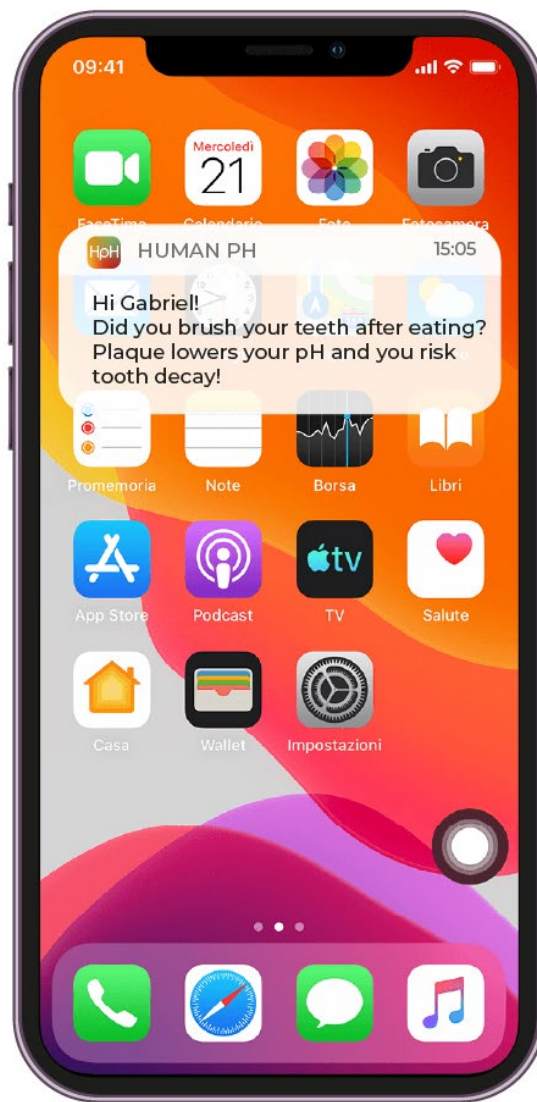


Figure 31. At mealtimes, users receive reminders to brush their teeth, a simple but essential step in preventing oral diseases.



Figure 32. Users are reminded to stay hydrated with reminders throughout the day.



Figure 33. Users are reminded to take daily measurements to ensure consistency and continuity in monitoring.

13. TECHNOLOGY SELECTION

We then hypothesized the type of technology best suited to this type of application. The three options were:

a) Native (high performance, more expensive)

iOS: Swift/Objective-C + Xcode

Android: Kotlin/Java + Android Studio

Native technologies are apps developed in languages specific to each operating system.

For iOS, this is Swift or Objective-C, while for Android, it's Kotlin or Java.

The pros of these technologies are maximum performance and full access to the hardware and native APIs. The cons are separate development for each platform, which is more expensive and slower.

b) Cross-platform (shared code between platforms)

Flutter (Dart): Reactive UI, high performance

React Native (JavaScript): High flexibility, large community

Ionic (HTML/CSS/JS): Preferred for hybrid apps

Cross-platform technologies are technologies in which a single code base runs on multiple platforms (iOS, Android). This saves time and costs and allows for the maintenance of a single version of the app. In some complex cases, performance is slightly lower than native technologies.

Among these, Flutter (Dart language) is a Google framework for cross-platform development. It features a responsive UI, near-native performance, and is very flexible.

Dart, however, is less well-known than other languages and has a growing but younger community.

React Native (JavaScript) is a Meta/Facebook framework that uses JavaScript. Featuring a large community, it has good integration with web libraries and good performance.

However, some native functions require extra work, and not everything is 100% cross-platform.

Finally, Ionic (HTML/CSS/JavaScript) is a framework that creates hybrid apps based on web technologies. It's easy for those with a background in web development, but its performance can be slower for more complex apps.

c) No-code/Low-code (for MVPs or prototypes)

Adalo, Thunkable, Bubble, AppGyver

These are visual platforms for creating apps with no (or little) code, making them quick to create MVPs or prototypes, and ideal for non-developers. However, they have some limitations regarding customization, scalability, and performance.

Native development proved to be the most suitable technology for this app.

It offers several advantages:

1. *Full Hardware Access*: It offers the best control and maximum reliability for integration with Bluetooth sensors or other external medical devices.
2. *Optimal Performance*: It ensures a smooth, responsive user experience with maximum performance, essential for a health monitoring app.
3. *Consistent User Interface*: It follows the specific design guidelines of iOS and Android, providing a familiar and intuitive interface.
4. *Stability*: Less likely to experience bugs related to interaction with the hardware or operating system.

Among the disadvantages, it is worth noting that it has both higher costs and longer development times: maintenance and updates must be managed on two separate code bases.

14. APP DEVELOPMENT

We then studied how the app will be developed and which phases need to be followed.

a) Mobile Frontend

This is the part of the app that the user sees and interacts with (UI - User Interface).

Includes:

- *UI (User Interface)*: buttons, screens, graphics, text input, colors, icons, etc.
- *User Interaction*: how the app responds to your taps, swipes, scrolls, etc.
- *Animations*: visual effects to make the experience smooth and enjoyable.
- *State Management*: keeps track of what's happening in the app (e.g., values entered, active screen, user logged in or not, etc.).

This can be done with tools like:

- Redux (used in React/React Native)
- Bloc or Riverpod (used in Flutter)

b) Mobile Backend

This is the "hidden" part that works behind the scenes. It's needed if the app needs to save data, register users, or perform complex calculations.

Includes:

- *Database*: where data is stored (e.g., recorded pH, user profiles).
- *Authentication*: Login, registration, secure access.
- *Server logic*: Automated rules and processes, e.g., sending reminders or analyzing data.
- *REST or GraphQL APIs*: Channels that connect the frontend and the backend to exchange data in a structured way.

c) Database

A database is a space where an app stores, organizes, and retrieves data in a structured way. For example, recorded pH values, user profiles, personal settings, etc.

Main Database Types

1. SQL (Relational)

SQLs use tables (similar to Excel spreadsheets with rows and columns). The data is organized according to fixed rules (schema) and is ideal for well-structured and interconnected data (e.g., users, measurements, settings). SQL-like languages are used to query them (e.g., "give me all of Mario's pH values for the last 30 days"). Examples: PostgreSQL, MySQL, SQLite

2. NoSQL (Non-relational)

NoSQL databases present flexible data, stored in documents (such as JSON), without a fixed schema. They are ideal for mobile apps, prototypes, or systems with variable or less structured data because they are easier to scale and modify on the fly. Examples: MongoDB, Firebase Firestore

d) Autenticazione e sicurezza

1. Login (email, social, biometric)

This is the process by which a user proves who they are to access the app.

Examples of logins include:

- *Email and password*: The classic method involves entering your email address and a secret password.
- *Social login*: You use Google, Facebook, Apple, etc. accounts to quickly log in without creating a new account.
- *Biometric*: Recognition via fingerprint, face (Face ID), etc. Offers quick and secure access.

2. JWT Token, OAuth 2.0

These are methods for managing and protecting access after logging in:

JWT (JSON Web Token): A digital "token" that confirms your authentication. The app uses it to verify

your identity without having to ask for your password each time.

OAuth 2.0: A protocol that allows an app to use your account from another service (e.g., Google) to authenticate you without sharing your password.

3. Encryption of sensitive data

This is the process of transforming data so that it is unreadable without the right key. It is used to protect personal information (e.g., passwords, medical data, phone numbers). Even if a hacker gains access to the data, they cannot read it without the key. Encryption is used in databases and communications (e.g., when sending data to the app) to increase security.

15. TESTING

This is the verification process to ensure that the app functions correctly and without errors. It helps find errors before the app reaches users, ensuring a good experience and functionality.

There are 3 main testing methods:

1. Unit Testing

This tests individual functions or small parts of the code to verify that each basic component works as expected. For example, testing that a function that calculates pH returns the correct value.

2. Widget/UI Testing

Check the user interface: buttons, screens, visual elements, and verify that the user can interact with the app without problems (e.g., clicking a button opens the correct screen).

For example: test that the "send pH data" button works and changes color when pressed.

3. Integration Testing

Test complete flows, i.e., multiple components together, and verify that different parts of the app work well together, such as login + data loading + notifications.

For example: verify that, after entering the pH, the data is saved and displayed correctly in the history.

Commonly used tools are:

- *XCTest*: for testing iOS (Apple) apps.
- *Espresso*: for testing Android apps.
- *Flutter Test*: integrated testing framework for Flutter apps.
- *Detox*: used for end-to-end testing on React Native apps.

16. PUBLISHING ON STORE

Once the app is finished, it must be published to a store.

Publishing an app on the official stores (Apple or Google) requires some technical and administrative steps.

a) Apple App Store (for iPhone/iPad)

- *Apple Developer Account*

This is required to publish apps on the App Store and access Apple tools.

- *Compiling with Xcode*

Xcode is Apple's program for creating and packaging iOS apps; it also allows you to sign them with official certificates.

- *Provisioning Profile Certificates*

These identify you as an authorized developer and allow you to install your app on real devices and submit it to the App Store.

- *TestFlight (beta testing)*

This is an Apple platform for users to test your app before publishing and is very useful for gathering feedback.

- *App Store Connect*

This is the portal where you enter the description, images, category, privacy policy, etc. From here,

you submit your app to Apple for review (approval).

b) Google Play Store (for Android)

- *Google Developer Account*

This is an account that allows you to publish apps on the Play Store.

- *Generate APK or AAB files*

You must generate either APK (Android Package) or AAB (Android App Bundle, more modern) files.

- *Google Play Console*

This is the portal where you upload your app, enter the title, description, screenshot, rating, etc.

- *Review & Release*

After uploading, Google reviews the app (which can take anywhere from a few hours to a few days).

If approved, it can be published immediately or scheduled for release.

This is followed by uploading to the Google Play Console, reviewing, rating, and release.

17. MAINTENANCE AND UPDATES

1. Bug Tracking (Crashlytics, Sentry)

Once the app is published, errors or crashes may occur on some devices or operating system versions.

For this reason, real-time monitoring tools are used, such as:

- *Crashlytics (by Firebase)*: detects crashes and runtime errors and reports them with useful details (type of error, device, user involved).
- *Sentry*: similar to Crashlytics, but more flexible, used to track bugs in both the frontend and backend.

The goal is to quickly fix issues to improve the user experience and stability of the app.

2. Regular Updates

After launch, it is important to keep the app secure, compatible, and up-to-date. You need to be able to adapt to changes in operating systems (iOS/Android), update libraries and dependencies, add new features, and continuously improve performance and security.

Updates can be corrective (bug fixes), enhancements, or evolutionary (new features).

3. User Feedback and Roadmap

After launch, users begin to provide feedback on features, issues, and suggestions.

This is collected through reviews, in-app forms, emails, and tools like Hotjar, Typeform, etc. Feedback guides the roadmap: a list of future improvements/features, sorted by priority and impact, i.e., the planning of the app's next releases.

18. ANALYTICS AND MARKETING

This final phase allows you to grow the app and strategically improve it, starting with data and user engagement.

1. Analytics – Analysis Tools

These tools help you understand how users use the app, where they click, how long they stay, where they get stuck, etc.

They are:

- *Google Firebase Analytics*: tracks custom events, conversion funnels, active users, retention, etc.
- *Mixpanel*: advanced user behavior analysis, excellent for apps with complex interactions.
- *Appsflyer*: Used to attribute installs to advertising campaigns (where users come from), very useful in mobile marketing.

Their goal is to improve the app based on real data.

2. ASO (App Store Optimization)

This helps make the app easier to find on the Apple Store and Google Play.

- *App name*: clear and relevant.
- *Description*: clearly explain what it does, using keywords.
- *Keywords*: used for search engine positioning.
- *Screenshots and videos*: attract attention and showcase features.

ASO is like SEO (Search Engine Optimization), but for apps.

3. Marketing – Promotion and User Growth

To attract and retain users, you can use:

- *Social campaigns*: on Instagram, Facebook, TikTok, LinkedIn, depending on the target audience.
- *In-app advertising*: promotions between apps or on mobile advertising networks.
- *Community*: create a space (forum, Facebook group, Discord, etc.) to engage users, collect feedback, and build loyalty

19. DISCUSSION

Primary prevention refers to all those actions taken to prevent the onset of a disease or health problem before it even occurs.

The goal is to remove risk factors or reduce the likelihood of an individual becoming ill by intervening on healthy individuals who are potentially at risk.

According to the WHO definition, *"Primary prevention consists of actions aimed at removing or reducing exposure to risk factors and promoting the adoption of healthy behaviors and lifestyles to prevent the onset of disease"*.

The main benefits of primary prevention are the long-term impact on public health and the economic sustainability of the healthcare system.

Primary prevention activities are not limited to the strictly medical field, but also include social and environmental actions:

- *Adopting healthy lifestyles:* Eating a balanced diet, staying properly hydrated, engaging in regular physical activity, and maintaining a healthy body weight.
- *Eliminating harmful habits, such as quitting smoking and avoiding alcohol abuse.*
- *Immunization:* Preventive vaccinations against infectious diseases such as measles, influenza, or human papillomavirus (HPV).
- *Occupational and environmental safety,* including the use of protective equipment and improving air and water quality to prevent exposure to harmful substances (such as asbestos).
- *Health education:* Information campaigns to raise public awareness of risks and appropriate behaviors.

The healthcare system is optimized to address existing health problems (treatment and secondary prevention) because these interventions are easier to finance, measure, and implement than primary prevention, whose benefits, while enormous in the long term, are less immediate and more complex to achieve. From an economic perspective, investments in treatment and secondary prevention (such as screening) deliver visible and measurable results relatively quickly (symptom reduction, recovery, disease stabilization). Primary prevention, such as anti-smoking campaigns or physical activity promotion, generates long-term benefits (decades), making it less attractive for annual budget cycles or policymakers. Much of the healthcare system relies on "pay-per-service" or the treatment of existing conditions. Hospitals, clinics, and pharmaceutical companies generate significant profits from the treatment of chronic diseases (e.g., diabetes, hypertension, cancer). There is no equally robust economic model for incentivizing long-term health. Although primary prevention is generally more cost-effective in the long run, it requires significant upfront investments in infrastructure (e.g., bike paths, parks, etc.), public education, and mass screening programs, which are difficult to finance.

From a policy perspective and in managing healthcare funding, the visibility and measurability of outcomes is much more tangible in treatment or a course of chemotherapy. In the case of primary prevention, such long-term results are more difficult to measure and therefore less visible.

Primary prevention also often requires significant lifestyle changes (diet, exercise, smoking cessation). These changes are notoriously difficult to implement on a large scale and require significant individual and social commitment.

Modern medicine has developed incredibly sophisticated tools for early diagnosis (secondary prevention), such as mammograms, colonoscopies, and cholesterol screenings, which are easy to implement and whose benefits are supported by solid scientific evidence.

New technologies, particularly health apps (mHealth - mobile health), have significant potential to promote and implement primary prevention among the population. They empower users to actively manage their health and modify risky behaviors.

Apps are particularly effective in supporting behavioral changes, a key pillar of primary prevention (such as smoking cessation, improving diet, and increasing physical activity).

Apps enable real-time monitoring and continuous collection of personal data (e.g., steps, calories, sleep, and vital signs when connected to sensors). This continuous behavioral feedback is a powerful driver of change. Studies have shown that mHealth interventions can generate small to moderate

increases in physical activity, a key factor in preventing chronic diseases.

Several apps apply Behavior Change Techniques (BCTs), incorporating scientifically validated psychological and behavioral techniques. Techniques such as goal setting, instructions on how to perform a behavior, and performance feedback are among the most effective. Apps that utilize these techniques in a multifaceted manner show better results in adherence to healthy behaviors.

Digital technology allows for personalized interventions, such as prevention plans, to be offered based on user data, risk factors, preferences, and progress. This increases engagement and intervention effectiveness. Personalization and individualization of goals have been identified as crucial to the success of mHealth interventions.

Interventions are also adaptive and timely: apps can send just-in-time notifications and reminders, for example, reminding people to drink water, take an active break, or take a medication, intervening precisely when needed.

Mobile technology has gained mass penetration, allowing us to reach segments of the population that are difficult to engage with traditional methods. With the widespread diffusion of smartphones, apps make health information and prevention tools accessible anywhere, anytime, breaking down geographical and logistical barriers. They are, in fact, highly effective in fostering patient empowerment, transforming the citizen's role from passive to proactive in managing their own health. By providing information and monitoring tools, people are empowered to become active participants in their own well-being.

Modifying people's lifestyles, and specifically, developing healthy habits, is a notoriously complex process. This difficulty stems from a combination of psychological, biological, social, and economic factors that work synergistically.

Our brains are hardwired to conserve energy and seek immediate gratification, which contradicts the nature of healthy habits.

Unhealthy behaviors like eating high-calorie foods, smoking, and lazing around activate the brain's reward system, releasing dopamine, which generates immediate pleasure. Healthy habits (exercise, a balanced diet) offer long-term benefits, but they often require effort and don't offer the same instant gratification.

Other factors include the psychological concept of the Habit Loop and the concept of Psychological Homeostasis. According to the Habit Loop theory, habits are deeply ingrained routines in the brain to conserve energy (the loop composed of cue, routine, and reward) (Graybiel AM, 2008). Breaking this loop requires considerable cognitive effort and awareness, making relapse into a pre-existing habit the path of least resistance (Lally et al., 2010). The theory of Psychological Homeostasis translates into resistance to change, which is widespread among humans, who tend to prefer stability and familiarity (Sterling P., 2012). Change, even if positive, generates uncertainty, stress, and anxiety, leading many people to avoid the necessary effort. The context in which we live has a significant impact on our choices, often stronger than our individual willpower (Peters A et al, 2017). Modern society is often structured to promote unhealthy choices. Ultra-processed foods and fast food are cheap, accessible, and widely advertised, while healthy foods can be more expensive and less available to some less affluent segments of the population. Social pressure and cultural norms profoundly influence ours. If everyone around us has sedentary habits or smokes, it's much more difficult to maintain virtuous behavior.

Marketing and advertising now pervade our lives: the tobacco, alcohol, and junk food industries invest billions to create desire and normalize consumption of their products, making healthy choices a constant battle against persuasive messages.

Furthermore, healthy choices aren't always the easiest or cheapest. Often, the least healthy options are the cheapest. Maintaining a diet rich in fruits, vegetables, and lean proteins can be expensive. Likewise, access to gyms, personal trainers, or sports classes isn't equal for everyone. Added to this is the widespread lack of time and resources: many people work long shifts or have family

commitments that drastically reduce the time and energy available to cook healthy meals or engage in physical activity.

Primary prevention has an intrinsic challenge: providing long-term benefits vs. short-term costs: acquiring a virtuous habit has an immediate cost (effort, sacrifice, effort), but the benefit (reducing the risk of disease in 20 years) is abstract and distant. It's difficult to motivate yourself today for an uncertain future reward.

The goal of the app we created is to combine the possibility of long-term benefits in terms of health and quality of life, providing a low-cost tool that requires only a little effort and consistency.

This approach benefits not only the user personally, but society, as those who manage to improve their healthy lifestyle will reduce their risk of developing a disease, thus reducing costs for the National Health Service and, therefore, for society.

The app's goal is to encourage users to make lifestyle changes (one of the primary objectives of primary prevention), using pH monitoring as a pretext. This useful and indicative value, but it does not fully summarize a patient's overall health, is a useful indicator.

The use of litmus paper as a measurement tool is the result of evaluating various commercial pH meters (Lutron pH-230SD, €180; Horiba Twin, approximately €140; and Hanna HI780c pH Checker Tester, approximately €190), which, being excessively expensive, could have deterred users from using the app. To gather useful information for modifying diet, hydration, breathing, exercise, and oral hygiene, a precise decimal calculation isn't necessary (we don't evaluate chemical reactions), but it's generally sufficient to know whether the pH is acidic, very acidic, neutral, basic, or very basic. Litmus papers are perfect for this purpose. They're also extremely inexpensive, easy to find, and portable, allowing you to measure even when traveling (unlike toilet sensors, which can only be used at home and not in shared toilets).

The analyses conducted for the app's design allowed us to clarify the project's focus and structure the app in a coherent and organized manner.

The SWOT analysis allowed us to evaluate the strengths, weaknesses, opportunities, and threats.

This app enables concrete primary prevention: it features generic indications in the basic version and more personalized programs in the advanced version. The idea is to support users in their decisions by a highly specialized team working remotely: a doctor, a nutritionist, a physiotherapist, and a dentist. The advanced option also allows for video calls for online consultations: this allows for healthy and safe lifestyle changes, especially if you suffer from a medical condition or are taking medication.

Although this thesis describes some nutritional supplements effective in managing acid-base balance, their use cannot and should not be taken lightly by the user, as it could prove harmful or the supplements themselves could later be found to interfere with ongoing drug therapy or compromise the resolution of a disease. For these reasons, I have avoided including the term "supplements," as it is risky and difficult to control. They can be prescribed by the team of experts only after a more thorough assessment of the patient's profile.

When modifying lifestyles, having the ability to refer to objective data can help a person both in determining the type of changes to undertake and in reinforcing the continuity of virtuous attitudes, making them solid and long-lasting. Health and well-being are built daily, with great consistency. This app can be seen as a tool for transitioning from an unhealthy to a healthy lifestyle: I don't imagine the user will use the app for the rest of their life, but primarily for the period necessary for a change. The goal is not to build user loyalty or dependency on the app, but rather to teach the user new strategies for nutrition, hydration, breathing, exercise, and oral hygiene, which they can then evolve or modify as desired.

The app can also be a valuable aid for the professionals mentioned above, for managing patients in their clinical practice. Doctors, dentists, hygienists, nutritionists, and physical therapists or athletic trainers can monitor a patient's progress by checking their pH over time. For example, knowing that a patient's saliva pH never drops below 5.5 is extremely important for a dentist who focuses on

prevention. Preventing caries or periodontal disease is essential for avoiding unnecessary treatments, rehabilitation programs, and unnecessary expenses.

The app is essentially based on the principle of empowerment: the user learns to read their body's signals and actively engages in achieving balance and good health. In my clinical experience, I've noticed that the patient who truly "heals" isn't the one who relies on a doctor or therapist, but the one who decides to heal and seeks the support of a competent professional to do so. It's very different: in the first case, you ask an external person (a doctor, dentist, physiotherapist, nutritionist, etc.) to solve the problem; in the second, you are the protagonist of the change and commit to achieving it. This app places the user in this second situation.

Regarding weaknesses, high compliance can certainly be an obstacle to achieving the app's goals. But on the other hand, a single healthy meal isn't enough to reduce cholesterol levels, just as brushing your teeth once a month isn't enough to prevent tooth decay. If the patient is inconsistent, they won't be able to prevent anything but will wait for the disease to develop and then have to treat it by spending money on doctor visits, purchasing medications or supplements, and undergoing lengthy rehabilitation therapies, which only serve to stem or eliminate the pain, which will then recur later. The problem with this approach is that managing a patient with an acute or chronic disease is more complex than managing a healthy patient whose goal is to maintain optimal health. Chinese doctors of the past knew this well, charging if the patient stayed healthy and not if the patient became ill. This is the exact opposite of our Western approach.

Multiple measurements, and therefore good collaboration, are necessary both to consistently monitor oral hygiene and to assess whether current behaviors (nutrition, hydration, breathing exercises, physical activity) are adequate for improving pH or need to be modified. Once a balanced pH level has been achieved, and lifestyle changes have been made consistently and consistently, the app's frequency can be reduced to a few days a week.

The fact that the instruments chosen are external is because there is currently no pH sensor that can be connected directly to a smartphone, which would be inconvenient given the need to measure urine and saliva.

Litmus papers were chosen over other meters because they are extremely affordable and therefore accessible to everyone: litmus papers €2.89 vs. Withings U-Scan Nutrio €349.95/€429.96; litmus papers €2.89 vs. ...).

Test strips don't allow for highly precise measurement, but as we mentioned previously, we need a tool that can indicate whether the pH is acidic, neutral, or basic, and roughly by how much: having a pH of 6.65 or 6.8 makes no difference, especially since pH fluctuates based on many factors. However, having a pH consistently between 4 and 5 is a problem that needs to be solved.

Among other opportunities, using an app allows you to share your journey, challenges, and goal achievements with other users who also own the app. This is the idea behind creating a loyal in-app community focused on a healthy lifestyle. It's a key element that transforms the app from a simple, standalone tool to a dynamic ecosystem of support and motivation. A community's main strength is its ability to keep users engaged over time. When users feel part of a group with common interests or goals (such as monitoring pH, losing weight, or managing diabetes), they are less likely to abandon the app or switch to a competitor. A sense of belonging is created. Furthermore, a community provides a constant reason to open the app, participate in discussions, and interact with content or other members. Apps with active communities often see a 40% increase in user retention rates.

The community is an inexhaustible source of added value generated by the users themselves. User-generated content (UGC), such as discussions, reviews, suggestions, and success stories, adds authenticity and depth to the app. This content is often more trustworthy and relevant to other users than brand-generated content.

The community also serves as a direct and immediate channel for collecting feedback, suggestions for improvements, and bug reports, allowing the product to be improved based on users' real needs. Sharing experiences and mutual support are crucial, especially when facing personal challenges related to health or lifestyle changes, which are notoriously difficult to manage individually.

Users can share their progress, encourage each other, and create virtual challenges, keeping

momentum and spirits high. Mutual motivation is key when trying to transform boring habits into something fun. Communities create social cohesion and reduce feelings of isolation, which is important for mental health. Feeling understood by people who share similar experiences (e.g., managing a chronic condition) improves mood and reduces stress. Finally, members can exchange tips and solve small everyday problems, also reducing the burden on the app's customer support service.

Among the threats, it's worth mentioning the risk of rapid churn if the user doesn't perceive tangible results. Obviously, since this is primary prevention, results are long-term: what's immediately measurable is primarily proper management of urinary and salivary pH. If the user expects immediate results, they're unlikely to find what they're looking for in this app: health and well-being are the result of a long, ongoing process. In an app that focuses on lifestyle changes, where tangible results take time (e.g., weight loss, improved pH, stress reduction), preventing rapid churn is crucial. The key is to shift the focus from long-term end results to short-term incremental progress and emotional well-being. The main problem is the lack of immediate gratification.

The app should create artificial and instant gratification using intermediate metrics: instead of focusing solely on the end goal (e.g., "lowering cholesterol"), the app should track and celebrate daily or weekly metrics: for example, "You've reached 7 consecutive days of food tracking!" or "You drank your 2 liters of water today!" or "You brushed your teeth 3 times a day this week!"

A point system or "gamification" can also be used to transform adherence to the plan into a game with points, badges, and levels. Accumulating virtual badges for consistency provides an immediate dopamine reward that mimics the rewards of unhealthy behaviors.

Or try to maintain interest with "streaks" of consecutive days of activity. Breaking a streak is emotionally challenging, incentivizing the user to maintain the habit.

As previously mentioned, a peer community allows users to interact with others facing the same challenges. Sharing frustrations and successes creates empathy and motivation. Enabling users to become accountability partners, allowing users to connect with friends or family within the app, is also a good strategy. Accountability to another person significantly increases adherence to change programs.

Within a community, intermediate success stories are also a valid incentive to reduce abandonment: instead of showcasing only those who have reached the final goal, showcase the stories of those who are halfway through and have overcome initial difficulties.

Beyond community sharing, the app's customization and flexibility can also reduce the risk of abandonment: a plan that is too rigid quickly leads to frustration.

Adaptive plans should be designed: if the user skips a day or doesn't reach a goal, the app shouldn't punish them, but rather propose a flexible "recovery" plan or adjust goals realistically.

Users should also be constantly reminded of the reason they started the program (health, energy, oral health). Intrinsic motivation is more powerful than coercion.

Other features that can be implemented in the app include microlearning sessions: offering short articles, videos, or daily quizzes that explain why a certain behavior is important, even without immediate results. For example: "Why does it take your body 4 weeks to show the first signs of sustained improvement in urinary pH?"

VPC Value Proposition Canvas analysis and the results of the User Survey allowed us to structure the app by carefully considering the Customer Profile.

Users are generally proactive, health-conscious individuals who want to actively monitor their well-being, often in relation to specific medical conditions (e.g., kidney stones) or dietary goals. The primary users of medical apps like HpH are young adults between 30 and 40 years old, with a relatively high level of education (which has made them aware of the importance of adequate primary prevention), technological awareness, and who prefer to monitor their health independently, without

having to constantly visit medical facilities. Reading values using a camera was chosen because this type of user prefers non-invasive, self-monitoring that is quick and intuitive.

The Value Map allowed us to define the app's offering: simple and comprehensive, not confusing, yet capable of providing practical tools.

The information is provided through graphs or diagrams, also useful for monitoring over time.

The suggestions provided must be varied to engage different types of users: written texts, searchable scientific articles, food/water lists for food/water purchase recommendations, recipes for alkalizing drinks or well-balanced meals, video tutorials for breathing exercises, physical activity, and meditation.

Reminders are also proposed to help patients maintain continuity.

BMC analysis allowed us to envision the creation of two profiles: a basic one with free features, and a premium one with a fee. In the first case, the basic model refers to people in good health who need general and in-depth guidance for changing their habits. These people have a good level of autonomy and are capable of understanding their own bodies and their needs. In the second case, either the user has a medical condition or wants more personalized information from the app. We hypothesized that personalization could be handled by AI, but since we're in a healthcare sector, we preferred to imagine a team of experts.

The user survey we administered to a sample group allowed us to understand whether an app of this type would have a following among the population.

It emerged that the most suitable age group for using this app is young adults, between 18 and 45, in line with the average age range of medical app users.

The majority of respondents believe an app aimed at encouraging lifestyle changes is useful, although 30% are unsure whether urinary pH monitoring is beneficial for their health. This may be due to a lack of knowledge on the topic, given that 100% of respondents had never independently monitored urinary or salivary pH.

The main motivation for using an app like HpH appears to be nutritional, followed by the need to monitor general health and, then, oral health. Ten percent seek a pH monitoring app for help either monitoring their physical training or losing weight. pH is closely linked to the pH of foods, whether acidic or basic, and therefore to dietary habits. pH is a value commonly found in laboratory urine tests, so most respondents associate it with general health. Conversely, only 20% associate pH measurement with oral health, likely because the dental world focuses primarily on the risk of plaque and the risk of sugar intake leading to tooth decay, before moving on to plaque removal methods and the need for frequent dental checkups.

Consistent with the above, most users would like nutritional advice and lists of foods to consume. The majority found reminders useful to help them manage a pH app on an ongoing basis, and about half would appreciate weekly or monthly reports and being part of a user community. This confirms the user's need for ongoing monitoring, sharing their journey with others, and being supported and informed about their progress. Objectifying a lifestyle change through numerical data such as pH values is considered by most respondents to be a key benefit of this type of app.

Most users are open to a personalized version: they are willing to change, but want to do so with scientific medical support that guarantees the quality and effectiveness of the change process.

20. CONCLUSION

In conclusion, we believe that this type of mHealth app project can provide the affected population with valuable support, encouraging them to make simple and immediate lifestyle changes. It is a useful tool for both individuals and the community: the NHS stands to benefit first and foremost from a large number of people committed to preventing degenerative diseases, resulting in a reduction in hospital and outpatient visits. Increased primary prevention leads to a reduction in the use of medications and surgical procedures, a reduced need for invasive medical treatments, a reduction in public and private healthcare spending, an improvement in overall public health, and an increase in work productivity.

The possibility of integrating with smart devices in the future should certainly be considered in a project to expand the service for users.

The pHp app could develop various devices:

- a dedicated pH meter sensor directly connected to the app to transfer results to the application in real time. This could extend the measurements to other parameters detectable from urine, such as hydration (specific gravity), the presence of ketones, and vitamin C levels.
- a toothbrush with a built-in pH meter: the patient could brush their teeth before applying toothpaste and measure the pH level in their mouth, then choose the most appropriate toothpaste and adjust their diet and hydration.
- a water bottle equipped with sensors that monitors the user's hydration status, hydration frequency, and fluid intake, and sends reminders or audible alarms to encourage the user to hydrate.
- a dedicated smartwatch capable of monitoring heart rate, blood oxygen saturation (SpO₂), blood pressure (arterial pressure), stress levels (using a combination of data, particularly heart rate variability (HRV), some smartwatches estimate and track stress levels throughout the day), a pedometer and distance travelled, and body composition (some models use impedance analysis). Bioelectrical Analysis (BIA) to estimate fat mass, muscle mass, and body water) and sleep monitoring (some smartwatches feature sensors that track the different sleep stages (light, deep, REM) and total sleep duration, providing a score or analysis of sleep quality).

Further studies are needed to understand the feasibility of creating and using a pH monitoring app: app development, testing, and potential publication. This is a complex and very costly process in terms of both time and money. The ability to pair a smartphone with dedicated devices (digital pH meter, toothbrush with pH meter, water bottle with sensors, smartwatches for breathing exercises, relaxation, and physical activity) could contribute to enriching this project and encouraging more people to use apps of this type.

This research project reflects my hope: that the future of medicine will increasingly evolve toward a massive increase in primary prevention. Preventing disease from occurring reduces patient management costs for the NHS, reduces drug use by reducing the risk of side effects and improves people's quality of life and mood.

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