

XPECTATION

PERSONALIZED EXPLAINABLE ARTIFICIAL INTELLIGENCE FOR
DECENTRALIZED AGENTS WITH HETEROGENEOUS KNOWLEDGE

D5.1

Technical report detailing architectural,
ethical, and societal requirements

[M16]

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Introduction

Virtual coach systems (VCS) are computational systems that guide users to achieve their goals through conversational interfaces. VCS support and complement the work of professional doctors (i.e., nutritionists) or domain experts, alleviating their workload and enabling them to assist more and better their patients. VCS have recently gained high notoriety due to technological advances in AI (including structured reasoners and Large Language Models LLM). VCS can leverage web, mobile and robot-based interfaces (i.e., QTrobot [3]) via text messages, structured menus, and voice interactions.

VCS have also proven effective in helping users adopt healthy habits (i.e., quit addictions, increase physical activity, and improve nutritional practices) -- yet, widely agreed, lacking personalization and explainability/trustworthiness. Thus, the EXPECTATION project aims to design and develop a Nutritional Virtual Coach (NVC) system to promote explainable and personalized healthy dietary habits.

Overall, NVCs promote behavioral changes in nutrition to improve eating patterns and users' health conditions. Therefore, the requirements span architectural/technical, ethical, and social areas.

Architectural Requirements

Before elaborating the architectural requirements, it is necessary to investigate the NVC's operational areas which are reflected within the internal (data) structure, functions and responsibilities. In turn, we present the both functional (FR) and non-functional (NFR) requirements directly impacting architectural design, development, and deployment.

NVC anatomy

Figure 1 schematizes the NVC composition: four primary submodules or subsystems [1].

- **Personalized food recommender systems:** it produces food recommendations and explanations based on the user's characteristics, previous interactions, and user's fitness and nutritional goals.
- **Persuasion techniques:** it enables persuasion strategies between the NVC and the user to change their behavior and encourage them to adopt healthy diet habits.
- **Argumentative techniques:** it employs logic to produce arguments and open a negotiation process with the user to learn from the user's feedback and reach an agreement on conflicting situations.
- **Informative and assistive systems:** it encapsulates methods, behaviors, and interfaces that allow the agent to communicate with the user and expose its behavior and knowledge through conversational (i.e., chatbots) and cyber-physical (e.g., Robots, virtual assistants).

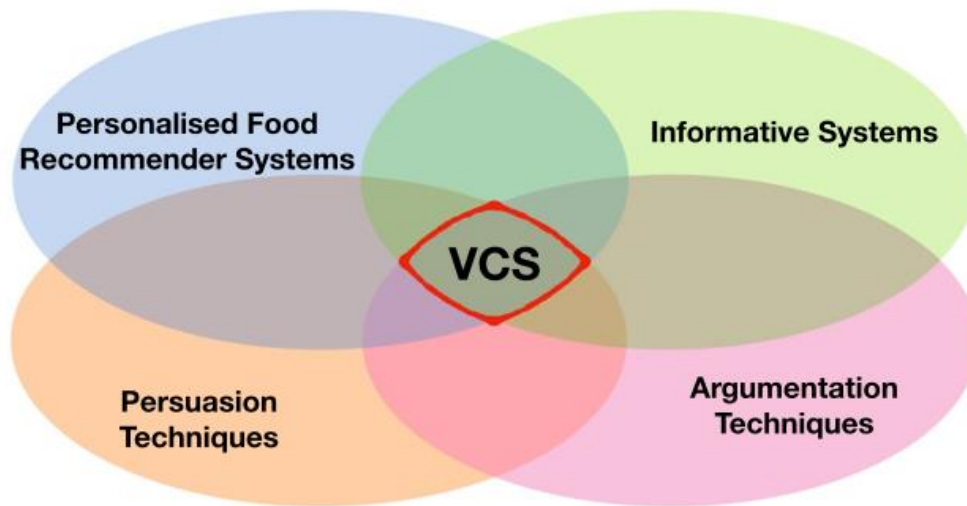


Figure 1: Schematization of submodule composition of virtual coaching system (VCS) in general, NVC in particular.

The NVC's internal organization described above establishes a primary responsibility definition between the submodules. As each submodule has a clear set of responsibilities that determines its behavior, it has its own requirements.

The following subsections pose the system's FR and NFR alongside architectural designs product of architectural decisions taken based on requirements, technologies, and restrictions. Architectural design is introduced through different viewpoints (i.e., conceptual, agents, interactions, and technical views). Each viewpoint delivers a different system perspective, allowing us to understand better the system and decisions taken to satisfy the requirements.

NVC Functional Requirements

FR describe the system's expected behavior and functionality. Table 1 describes the elicited functional requirements for the system requirements:

ID	Title	Description	Validation criteria	status
FR1	Front-end	The system should provide a mobile and web graphical user interface (GUI) to interact with the user.	Web and mobile GUIs are implemented and tested in the proof-of-concept product.	In progress
FR2	Proactive behavior	The agent should proactively produce food recommendations and reminders based on the user's preferences and habits/trajectory and send them through messages and notifications to the user.	The personalized agent can send notifications and messages to the user's endpoint (web/mobile) in the user's daily key time.	In progress
FR3	Multimodal communication	The system should be able to exchange multimodal data (i.e., text, image, and	The system is able to send and receive multimodal data (i.e.,	In progress

		audio) with the user.	text, audio, image) through the interface.	
FR4	User-agent exclusive mapping	Each user should be associated with one personal agent (PA), which is the only one able to access their profiling data and exchange (and process) the user's messages.	Each user has been assigned and interacts only with a PA.	done
FR5	Front-end and back-end decoupling	The systems should implement a Gateway Agent (GA) that bridges and routes the messages (to be normalized if necessary) from the user (front-end) to the related PA and back.	The system has a GA agent that redirects messages from a given mobile (e.g., telegram, whatsapp, ...) or web app to the PA and vice-versa.	done
FR6	Thematic behavior	The PA should implement a thematic (contextual) behavior that enables the necessary NVC's actions (i.e., provide recommendations, track food, identify meaningful restaurants, etc)	The PA agent implements a behavior contextualized into the nutrition domain, able to produce food/restaurant recommendations, tracking functionalities, and provide the due explanations.	In progress
FR7	Persuasive strategies	The PA agent should implement persuasive strategies introduced by the nutritionist and domain experts. In particular, the PA has to produce notifications and messages (e.g., suggestions/reminders) to enforce the user's behavioral change.	The PA agent implements interfaces and internal behaviors to design, assign, and execute persuasion strategies.	In progress
FR8	Agent-agent communications	PAs should be able to communicate with each other and with the GA to exchange knowledge.	Agents exchange messages between them to ask for additional pieces of information in case of need.	In progress
FR9	Personalized food recommendations	The PA should provide food recommendations (e.g., main meals, snacks, and breakfast) based on the user's profile information, goals, and trend.	The system generates recommendations according to the user's profile, goals and trends via neuro-symbolic integration techniques.	In progress
FR10	Personalized Restaurant recommendations	The PA should provide restaurant recommendations based on the user's profile, preferences, and current location.	The system can select and recommend restaurants around the user's location according to their preferences.	done
FR11	Food tracking	The PA should be able to track food consumption and compute the daily calorie intake.	The system can allow the user to record the consumed food items and approximate/associate the related calories	In progress
FR12	Data synchronization	The PA should be able to synchronize and import data from wearable garmens (e.g., Fitbit or other exercise-tracking sources).	The system can retrieve and use data from wearable devices (or external web services).	To do

FR13	User registration	A new user can create a new account, providing their personal data and email.	New users can register and create an account in Pryv (privacy-preserving DB and in the NVC).	done
FR14	User login	Registered users can log in using their credentials via several user interfaces.	Registered users can log into the system mutually-excluding inactive sessions.	done
FR15	User logout	Registered users can log out	Logged-in user can log out the application.	done
FR16	Dynamic consent	The system must ask the user the consent to access their personal data.	The system displays a consent message to the user detailing the data for which it is asking for authorization.	done
FR17	Receive general feedback	The system should receive users' feedback and store it.	The system is able to get and store users' feedback.	In progress

Table 1: Functional requirements for nutritional virtual coaching system.

Non-functional requirements

Non-functional requirements are an essential part of any system's design and development. These requirements go beyond the system's basic functionality and focus on the quality attributes necessary to meet stakeholder expectations. As such, they are critical to ensuring the system is effective and efficient. Some examples of non-functional requirements include performance, scalability, security, usability, and reliability. By carefully considering and addressing these requirements, developers can create a high-quality system that meets the needs of its users. The major non-functional requirements elicited for the system are described below:

ID	Title	Description	Validation criteria	status
NFR1	Data integrity	The systems should ensure data consistency across the several DBs and knowledge representation.	The data in the application is consistent and stored in the database.	In progress
NFR2	Multi-agent architecture	The systems should implement a multi-agent architecture, with a PA for each user and a GA for each contextual agent container.	The system relies on a multi-agent framework (i.e., SPADE).	done
NFR3	Data retention	The system should persist general (e.g., feedback, recipes) and personal (e.g., profile and behaviors) data	Personal and general data is functional data persisted in mongoDB and personal data persisted in Pryve	In progress

		in persistent databases.		
NFR4	Self-contained deployment	The system's backend should be deployed in a server through self-contained docker containers.	The backend is containerized and deployed in a web server.	done
NFR5	Disaster recovery	The system should be able to recover its last saved state if a disaster occurs.	The system implements mechanisms to save the current state and recover it on initialization.	To do
NFR6	Extensibility	The system should be open to extension, adding new functionalities without major modifications.	The system architecture is modular, with low coupling and high cohesion. The extension can come as Json instruction (profiling/persuasion FSM) raw or via a web page.	done
NFR7	Flexibility	The system should adjust to different configurations and platforms without significant changes.	The system follows a decoupled design between the backend and front ends.	done
NFR8	Integrability	The system should implement web APIs to expose its back-end services to different front ends (e.g., Hemerapp, Telegram, Messenger, Whatsapp).	Web API implementation	done
NFR9	Internationalization and localization	The system should implement localization mechanisms to answer the user in different languages according to the user's language configuration and localization.	The system can run in at least three different languages and is geo-location aware.	done
NFR10	Interoperability	The system is able to interact with other platforms and chat clients (i.e., Telegram, Messenger, Custom chat).	the GA bridges different platforms, adapting the message structure according to the target platform (both to and from the user).	In progress
NFR11	Fron-end compatibility	The front end should be compatible with mobile, desktop, and web platforms.	Implement the front end in a the system front-end interface has mobile and web compatibility.	done
NFR1	Privacy	The system should	The user's private are stored in a	In

2	(compliance with privacy laws)	guarantee the privacy of the user's data. Only the user, the PA, and the authorized doctor can access the user's personal data.	privacy-compliant database with access and consent regulated.	progress
NFR1 3	Portability	The system should be able to run different platforms with minimal modifications.	The back end and the front end are decoupled. The back end can be deployed as different instances on several VMs/servers.	done
NFR1 4	Security (cyber and physical)	Physical access to the server and other hardware or facilities is restricted and controlled. The backend should be deployed in a secure server implementing HTTPS communication protocol. The communication between containers is isolated from outside networks. Only the web server container is open to the internet.	The system complies with the due security measures.	In progress
NFR1 5	Transparency	The system should be able to expose and explain its internal decision process to the user to reduce opacity and increase the system's transparency.	The system produces explanations about its internal decision process and shares them with the user.	In progress

Table 2: Non-Functional requirements for nutritional virtual coaching system.

Architectural design

To satisfy the abovementioned requirements, a software platform (EREBOTS) has been designed. The EREBOTS architectural design is presented below from several viewpoints. Each viewpoint provides the required information to understand the system's behavior and its relationship with requirements.

Conceptual View

The abstract view describes the communication flow between the agents in the system. To satisfy the requirements: NFR2, FR8, FR9, the system has been designed following the multi-agent system (MAS) paradigm, where agents exchange messages to achieve their goals producing emerging behavior. Figure 2 illustrates the abstract view of EREBOTS systems, with the arrows

representing the communication channels between agents. The orange arrows schematize the communication between the PA and the user, complying with requirement FR8, each user communicates only with one PA, and a PA only serves one user creating a one-to-one relationship with the user. Similarly, in light-blue agent-agent communication, different from the previous case, PA agents can also communicate between themselves to share knowledge and find solutions to different problems (e.g., cold-start problems) while ensuring privacy and knowledge encapsulation. Finally, the green arrows show the communication channel between doctors and PA. Doctors design and introduce the best practices and persuasion strategies for the users, and the PA implements and adopts those practices and strategies.

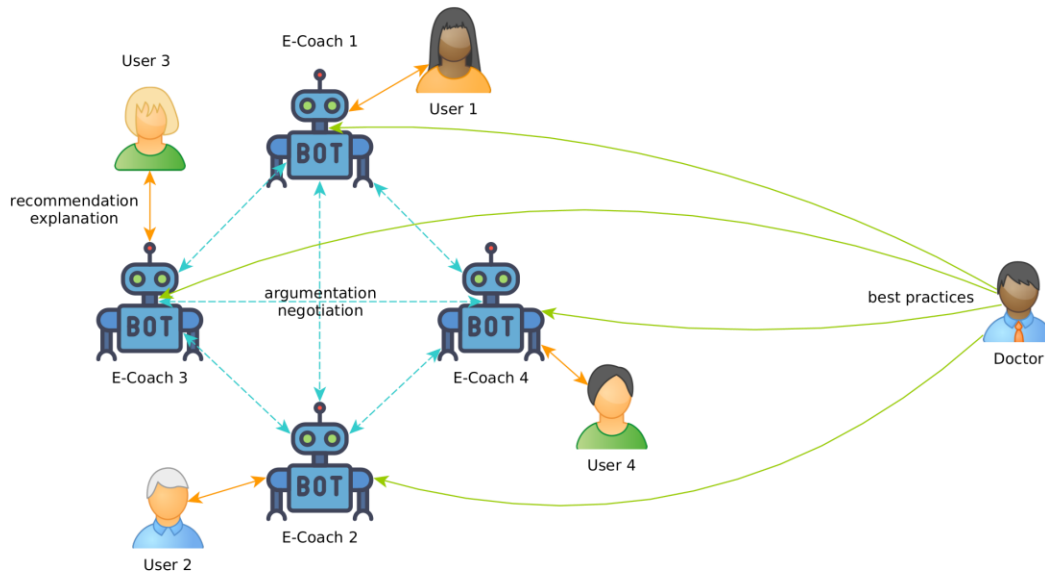


Figure 2: Abstract view schematization. Orange arrows represent recommendations and explanations, user-agent communication. Green arrows represent doctors' best practices and persuasion strategies. Agent-Agent communication argumentation and negotiation are represented in blue arrows.

Agents View

The agent view presents a detailed perspective of the agent's environment and interactions with users and other agents. For each user exists a context that determines the PA state and behavior for the given user (e.g., nutrition, rehabilitation, ecc). Each context includes a PA, which employs a logic reasoner module, and a data-driven (black-box) predictor, to produce personalized food recommendations, nudges, and explanations for the user. The feedback and updates from the user are stored in the local database. Finally, communication with the user is carried out through assistive and informative submodules employing different devices and conversational interfaces.

In addition to the user's context, Figure 2 shows the administrator context, where the doctor employing a web interface introduces the best practices and strategies for PA and can query the user's statistics and dashboard to follow the user's progress. Best practices and strategies are available to agents through a shared database.

When a new user registers, there are not enough interactions to make a personalized recommendation. This is known as the cold start problem. To solve this problem, a collaboration strategy between agents has been proposed. Agents share their experiences and aggregated knowledge (without disclosing sensitive details) to produce recommendations for the new users while they preserve the user's data privacy and security, according to requirements NFR12 and NFR14. For example, let us consider user 3 and user 4 in Figure 2 as new comers whose agents will interact with personal agents 1 and personal agent 2 to minimize the cold start effect.

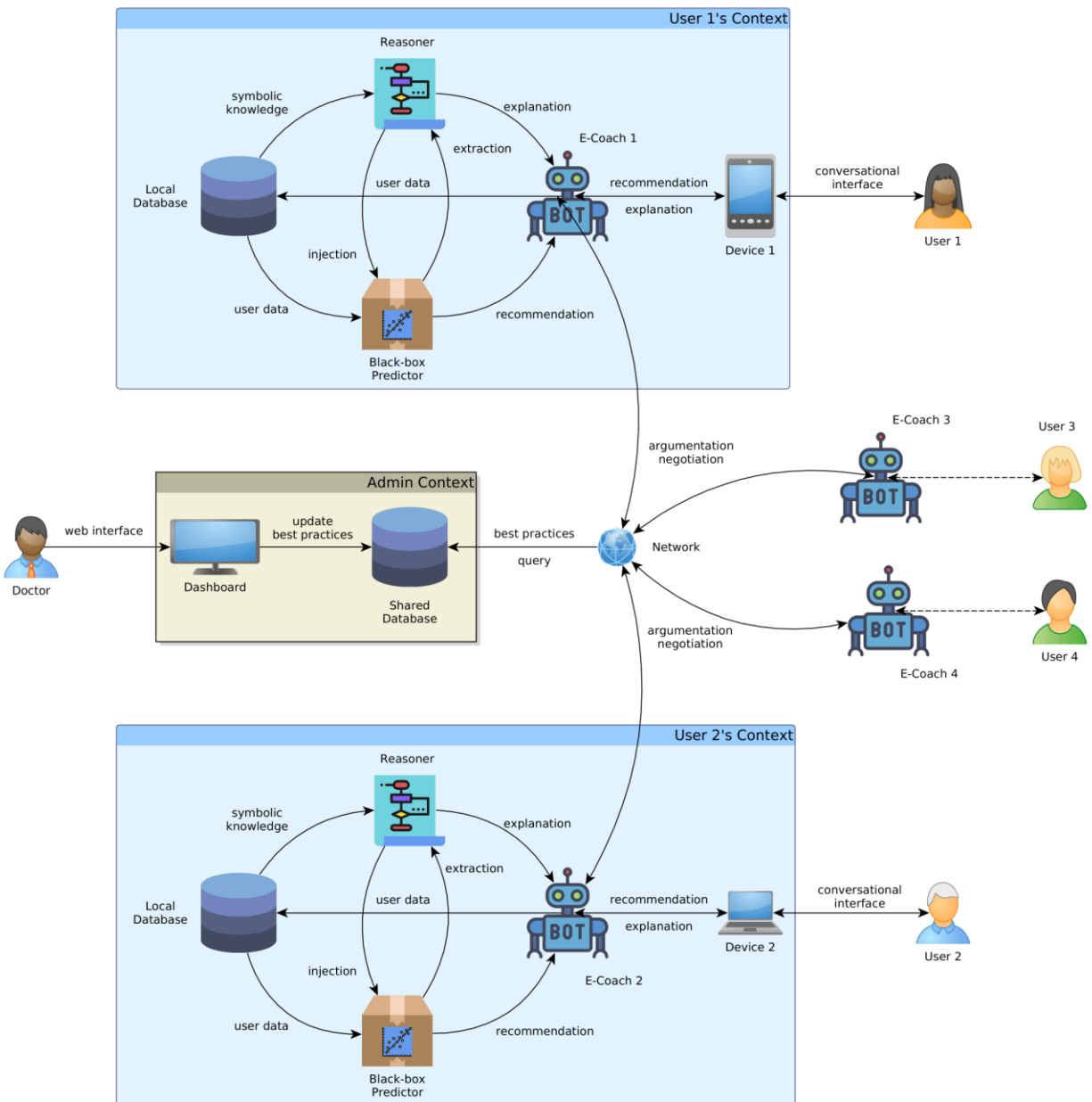


Figure 3: Agent viewpoint schematization for agents view. Blue boxes denote the user's context. Green boxes indicate the administrator context where doctors can design best practices and

strategies or follow the user's progress through statistics and dashboards. Arrows represent information flow.

Interactions View

The runtime view is similar to the agent's view while adding additional details to understand in depth of the communication mechanism between agents. As is shown in Figure 3, the agent's middleware contains two directories that allow the agents to find and communicate with other agents. Directories also allow agents to find and consume services offered by other agents or subsystems in the application, or consume third-party services through web services interfaces.

In Figure 3, we can distinguish two kinds of directories. On the one hand, we have the yellow page directory for finding and consuming web services; on the other hand, we have the white page directory for finding and contacting other agents. In addition to the directories, each agent has a message queue that behaves like a mailbox, where messages are received and temporarily stored till they are processed. Finally, the connection between the agents and the front end is mediated by web service, producing a low coupling high-cohesion system, a characteristic essential to fulfil the requirements NFR4, NFR5, NFR6, NFR7, NFR10, NFR11 and NFR13.

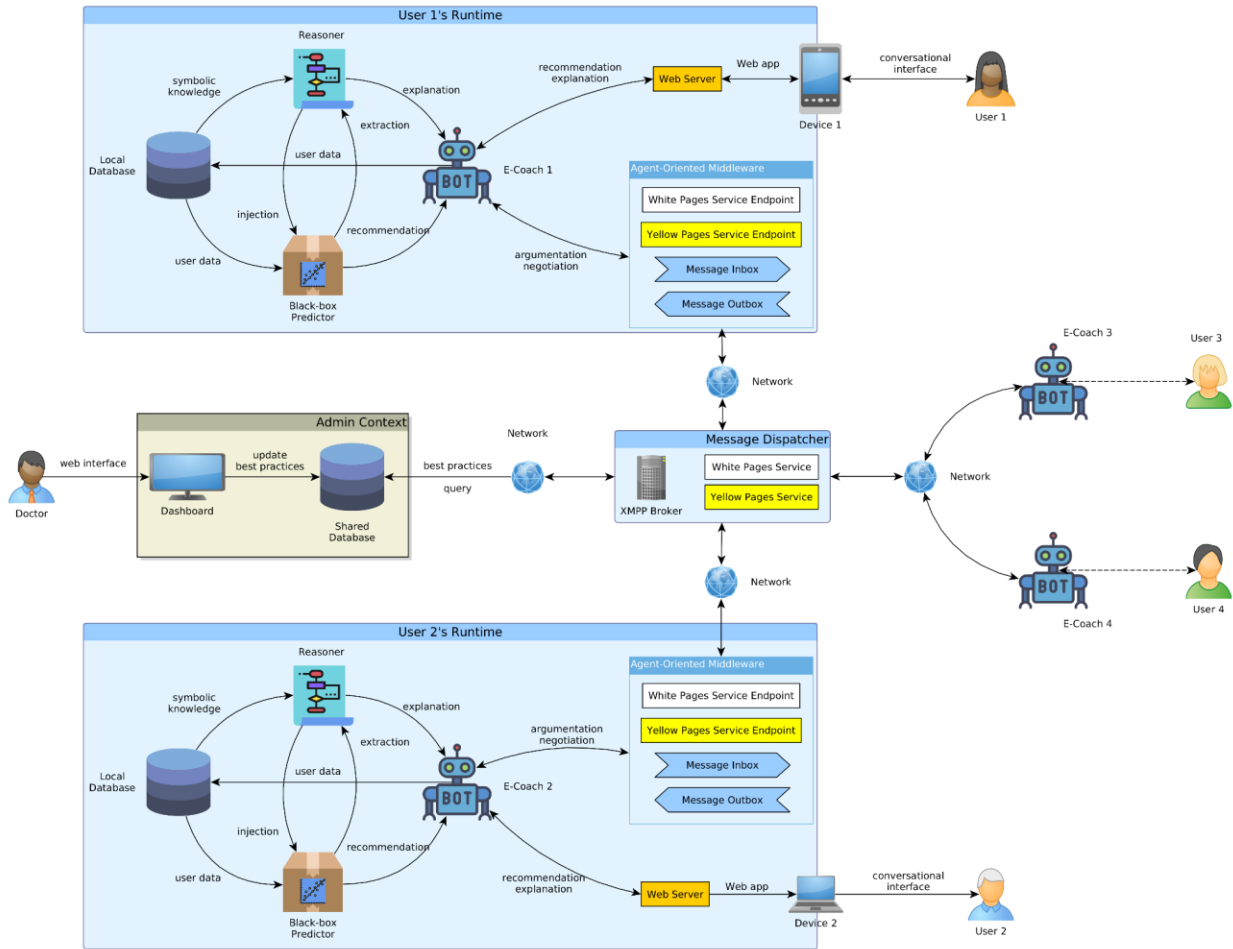


Figure 3: Runtime viewpoint schematization. Runtime view allows the understanding of the agent communication, explaining directories and mailboxes required to find other agents and send and receive messages.

Technological view: EREBOTS 2.0

The technological point of view provides an understanding of the technologies employed to develop the system. To fulfil the functional and non-functional requirements listed in Tables 1 and Table 2, the nutrition virtual coaches have been integrated into the multi-agent chat platform EREBOTS 2.0.

EREBOTS 2.0 platform is composed of two main parts: EREBOTS-core for the backend and Hemer-App for the frontend. EREBOTS-core has been developed on SPADE multi-agent framework [2]; Spade is used to create PA and GA agents, behaviors, and messages. Spade is developed in Python programming language and employs XMPP as a communication standard to exchange messages between agents. PA and GA agents in the backend exposed their services through a REST web service API developed in an asynchronous high-performance web framework, Fast API. The chosen XMPP server for EREBOTS 2.0 is the Prosody server because of its reliability and flexibility. Finally, EREBOTS-core integrates two NoSQL database systems to

store users and application data. MongoDB has been chosen as a shared database to store general feedback of the user, agents' state, best practices, and strategies introduced by the doctor. On the other hand, Pryv, a GDPR-compliant database, has been selected as storage for users' sensitive and personal data. Pryv database guarantees the user the control and ownership of their data through a dynamic consent mechanism, where the users are the only data owners, and they can grant or remove access to their data anytime without deleting it.

EREBOTS 2.0 can adopt chat-based frontends like Telegram, WhatsApp, and Messenger. However, the main frontend interface for EREBOTS is a custom chat application HemerApp, developed in Flutter mobile development framework, which allows the same application to be deployed on different platforms (i.e., web, Android, iOS, Windows, Linux, Mac) without major modifications.

EREBOTS 2.0 and its components are containerized, employing docker and docker-compose technologies to facilitate the deployment, scaling, and avoiding platform dependencies. Figure 4 illustrates technologies employed to deploy the system. Spade multi-agent system and backend web services are deployed in one docker container, which exposes their services through a secure communication protocol, HTTPS. The XMPP server, Prosody, is deployed in an independent container and linked with other containers through an internal network to preserve the security of the system. MongoDB is deployed in a separate container, and the Pryv database is consumed as a third-party service. Finally, the frontend is deployed in its respective container and connected to the backend using the HTTPS protocol.

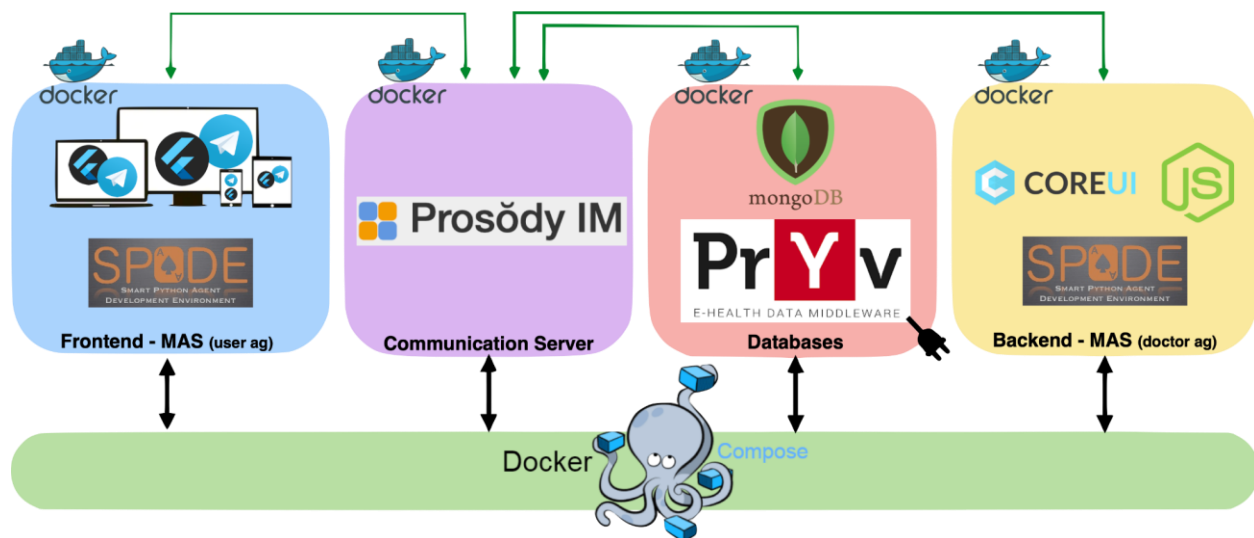


Figure 4: Deployment and technology diagram for EREBOTS 2.0. Containers compose the EREBOTS system from left to right: Frontend container, Prosody XMPP server, database server, and Spade multi-agent system backend.

Figure 5 shows a detailed information flow and the technologies involved in EREBOTS communication. A blue box in Figure 5 denotes the PA agent; each PA agent accesses its user profiling information, settings, and tokens for chat applications when it is required. PA agents

implement a thematic behavior, domain-specific behavior, which allows the agent to execute their functions as an expert coach in a given domain (e.g., nutrition). PA agents also implement a persuasive behavior that aims to change users' behaviors, beliefs, and habits. The GA agent implements directories and message composers to adapt messages to different platforms and redirect messages to the appropriate agent. Doctors or domain experts interact with the system through a web interface that queries the shared databases and the PA to obtain progress information about the users.

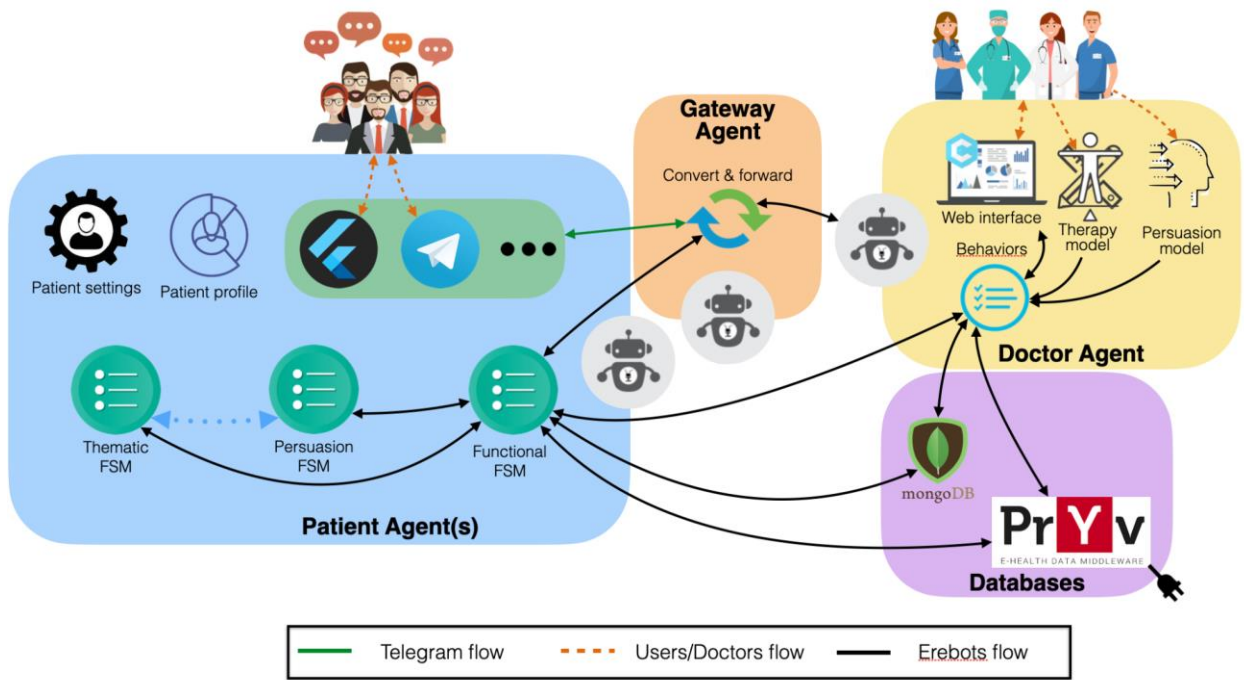


Figure 5: Information flow diagram for EREBOTS 2.0. In blue box, patient or personal agent (PA). In orange box, the gateway agent (GA). Yellow box denotes the doctor interface and magenta box denote the database services.

Figure 6 illustrates screenshots of HemerApp front end for EREBOTS 2.0 proof of concept. Moreover, it represents the user profile and the chain of interactions with the bot employing predefined answers shown in buttons. EREBOTS-core and HemerApp front end have been implemented as part of the proof of concept system.

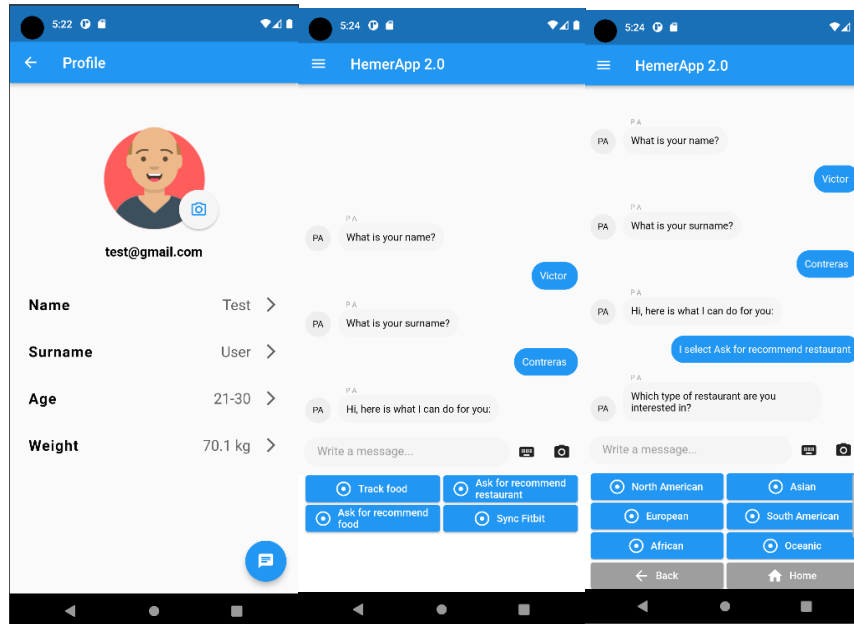


Figure 6: EREBOTS' front end HemerApp from left to right: i) User profile ii) Chat first screen iii) chat second screen.

Ethical Requirements

Since VCS could directly impact the psychological and physical health of the users, several ethical concerns have been raised as VCS has grown in popularity, particularly in safe-critical domain applications like those in the health and nutrition domains. We have identified and expressed ethical requirements in relationship to ethical challenges (EC) for the nutrition use case developed in the Expectation project. The identified ethical challenges per submodule are described below:

Food recommender system

The food recommender system (FRS) is the submodule in charge of providing food recommendations based on users' features. The following are the ethical challenges identified for this submodule:

- EC1.1 Health and moral damaging: The FRS should avoid providing inappropriate recommendations that could cause health or moral damage to the user.
- EC1.2 Privacy: The NVC should guarantee the user's data privacy and avoid sharing sensitive information with other agents.
- EC1.3 Personal identity threat: The FRS should safeguard the user's identity, avoiding intentionally limiting the user's choice freedom or manipulating the user's community to create a filter bubble hiding/ignoring the user's personal identity.
- EC1.4 Opacity: The FRS should provide transparent recommendations (i.e., providing recommendations with explanations).
- EC1.5 Biased recommendation: The FRS should adopt techniques for debiasing recommendations.

- EC1.6 Social pressure: The FRS should not promote political or social polarization, providing transparent recommendations based on the available data.

Argumentative systems

Argumentative systems (AS) are in charge of producing explanations and arguments and conducting negotiation protocols to lead the user to understand the NVC recommendations and decisions better and reach consensus decisions. The following are the ethical challenges identified for the argumentative submodule:

- EC2.1 Attain formal validity: Arguments generated by the argumentative system should be proved and based on true premises, validated on the available data.
- EC2.2 Leverage sole sincerity/truth: Arguments generated by AS should be based on true facts supported by data and reasoning processes. No conclusions should be derived from false or doubtful premises.
- EC2.3 Ensure content justice: Arguments should be formally validated as legal and moral with the current user and other users in the platform.
- EC2.4 Enact fair and just procedures: The AS should implement dialogue games and protocols that allow users to put forward their arguments and reasoning process as a contribution to the NVC.
- EC2.5 Compliance-verification coverage: The AS should evaluate their arguments and other agents' arguments employing the following methods: i) source/speaker reputation from MAS. ii) belief checking, enabling honest mistake recognition and correction if required.
- EC2.6 Simplify or aggregate arguments: The AS should implement a subsystem to select, prune, and aggregate statements providing a minimal extent of explanations, reducing its response time and argument complexity.
- EC2.7 Multimodal arguments: According to the context, AS could communicate arguments through several channels (e.g., audio, visual, or textual).

Informative and assistive systems

Assistive solutions made possible by current advances in artificial intelligence (AI), social robots, ambient intelligence, and wearable technology are together referred to as intelligent assistive technology (IAT).

These solutions focus primarily on caring for aged adults and those with special needs. The development of IAT has brought about several ethical issues, nevertheless. Notably, programs designed for sensitive users make excellent use of data collecting and function close to people. You can conceptualize the IAT's ethical issues as follows:

- EC3.1 Facilitate technology access: The IAT technology should be available for users with special needs (i.e., dementia or other mental disorders). However, the system is not a substitute for medical treatment, advice, or consent. Terms and conditions should be dynamic and approved by the user or the legal user tutor.
- EC3.2 Ensure the system identity: To ensure the correct employment of IAT tools, they should be employed under the supervision of trained personnel as an auxiliary tool to the

actual medical treatment or therapy, particularly for users with special conditions and needs.

- EC3.3 Ensure medical data confidentiality: IAT tools should provide a tracing mechanism to the user for the correct use and preservation of the user's medical or private data.
- EC3.4 Affordability of the proposed solutions: The app is a good choice for improving one's knowledge of nutrition and may help in promoting new healthy habits in one's daily life.
- EC3.5 To ensure safety boundaries: The responsibilities of the AIT system and the NVC should implement mechanisms that certify or monitor limits, safety, and pertinence of IAT services and behaviors.

Persuasive systems

When preparing for their adoption, it is vital to keep in mind that persuasive technologies expressly aim to persuade people. Particularly, legitimacy, honesty, and manufacturing must be closely scrutinized to determine which interests (those of designers or consumers) are fulfilled and the actual contents.

- EC4.1 Persuasion/nudges awareness: The user must be aware of their exposure to persuasion techniques from the beginning of their interactions with the supplied system, using systems that clearly notify or warn them.
- EC4.2 Clear goals statements: A user approaching a persuasive system should be promptly informed of goals that have been formed in a complete, understandable, and timely manner. According to a recent study, the first step should be to provide an "information leaflet" informing the user of the persuasive system's objectives and procedure.
- EC4.3 Prevent unintended behavior change: the designer of the persuasion strategy should take responsibility for unintended, unforeseen, and unpredicted outcomes. Additionally, debuggable and explainable mechanisms should be implemented to track the user's behavioral change.

Based on ethical challenges identified before, ethical requirements (ER) have been elicited. Ethical requirements denote a solution or mitigation countermeasure to one or more ethical challenges and can overlap with one or several functional or non-functional requirements.

ID	Title	Description	Ethical challenges	Implementation status
ER1	Appropriate recommendations	According to the available information, recommendations should be precise and appropriate to the user to reduce the risk of physical or moral damage.	EC1.1, EC3.4	In progress
ER2	Privacy	Users' personal and medical	EC1.2, EC3.3	In progress

		data should be private, and only the PA agent should directly access this data.		
ER3	Identity protection	The system should provide counterfactual explanations to express the reason for choosing a given food item over others and inform the user of the availability of other options. This countermeasure avoids limiting users' choices and affecting their identity.	EC1.3	In progress
ER4	Transparency	The system should provide explanations to reduce the opacity and make the internal decision and reasoning process transparent to the user.	EC1.4	In progress
ER5	Bias mitigation	Bias cannot be totally avoided since it is part of the data, users, and sociopolitical context. However, it can be mitigated with statistical techniques (i.e., Normalization, scaling), simulated data, and rules.	EC1.5	In progress
ER6	Social pressure mitigation	Social pressure cannot be totally avoided, but it can mitigate by developing a trust and personal relationship between the user and the agent, reducing the social influence and polarization, and creating a safe space where the user can freely express himself.	EC1.6	In progress
ER7	Argument validity	All arguments produced by the system should be logically and formally validated based on facts and available data.	EC2.1, EC2.2, EC2.3	Not yet implemented
ER8	Fair argumentative procedure	The dialog design should include an argumentation and negotiation protocol that allows fair argument exchange and user expression. The user must be able to present his	EC2.4	In progress

		arguments, develop his reasoning, and evaluate and argue the agent's arguments.		
ER9	Argument coverage	The user's and agent's arguments should be validated and checked against trusted sources, considering the context and reputation and acknowledging mistakes and errors when they may occur.	EC2.5	Not yet implemented
ER10	Simply arguments	Arguments should be formulated simply and briefly, adjusting the language complexity and terminology to the user's knowledge level.	EC2.6	Not yet implemented
ER11	Multimodal communications	When presenting arguments and explanations, it is beneficial to use a variety of media channels such as text, images, and audio. This ensures that information is conveyed effectively to all users and makes the content more engaging and interactive.	EC2.7	In progress
ER12	Technology access	In order to guarantee equitable access to virtual coaching technology, the system ought to provide a free version that is accessible to all users.	EC3.1	Implemented
ER13	Personal Agent identity	PA agents should develop a unique identity that aligns with the user's profile and interactions, and evolves as the user does. However, it's also essential to maintain coaching goals to ensure that the PA is always helpful and effective.	EC3.2	In progress
ER14	System boundaries	The system boundaries should be defined and expressed through the term and services agreement. The system's boundaries are not only limited to physical	EC3.5	In progress

		frontiers but also include interaction and responsibility limits. Therefore, all recommendations and advice provided by the system should be reviewed and approved by professionals in nutrition and medicine.		
ER15	Clear goals	When starting a diet, the NVC should clearly communicate its objectives to the user during the initial stages.	EC4.1	Implemented
ER16	Prevent unintended change behavior	The system should provide explanations and arguments related to the user's goals to support its decisions, and monitor the user's progression and behavioral change to avoid unintended behaviors.	EC4.1	In progress

Table 3: Ethical requirements (ER) based on ethical challenges (EC). Ethical requirements are related to one or more ethical challenges and overlaps with some functional or non-functional requirements.

Users study

Nutrition is a vital aspect of health and well-being, and concerns all people, regardless of their medical gender, age, ethnic group, region of residence, beliefs and so on. It is a key determinant of health. Despite its importance, many deviations due to negligence, ignorance, or just bad habits affect individuals. Therefore, the need for assistance is impelling. In the quest to realize a nutrition virtual coach system available to everyone, to help users to for their nutrition, we conducted a month-long survey via Internet to identify backgrounds, expectations, habits, etc. of the possible NVC's users. Table 4 summarizes the survey's outcomes. Appendix 1 organizes and explains the survey's results punctually.

ID	Title	Description	User expectations	NVC properties (characteristics)
US1	Personal experience with the virtual nutrition coach system	Highlight the needs and the best conditions for an interaction between the system and the users	<ul style="list-style-type: none"> -To use of the NVC on their Smartphone - To maintain the duration of a friendly chat between 1 to 3 minutes in the best, or 4 to 6 minutes in the worst case. - NVC must be non-intrusive and most of the interactions planned. - Explanations should be multimodal (text or video in case of misunderstanding or disapproval) 	<ul style="list-style-type: none"> - Multilingual - Adaptation to all digital media with a focus on Smartphones. - Interactive. - Illustrative. - Combine user initiative and system initiative interaction
US2	The definition of an explanation	Understanding the concept of explanation in a virtual nutrition coach system	<ul style="list-style-type: none"> -A clear explanation must be provided whenever necessary/asked. - An explanation could be a justification of the advice of the NVC; - An explanation could contribute to understand the reasons behind the advice of the NVC; - An explanation could add references especially if it is related to health; - An explanation could focus on user data such as health benefits, food 	<ul style="list-style-type: none"> - Provide text, video and image support to complement recommendations; - Adapt explanations to the user's profile (personalize the explanations)

			constraints, eating habits, religion, culture, and ethnicity; - An explanation could focus on recipe data such as taste, smells good, nice touch and loaded with nutrients, etc.	
	Privacy/ confidentiality	Establish the best possible security conditions for user data.	- Optimal data security; -A request for authorization before any distribution or sharing of data with third parties; - Systematic anonymization of user data. - The most suitable time to collect user data is when the system is starting	- Password-protected access; - A doctor can access user data under certain conditions; - A nutritionist can access certain user data under certain conditions; - Cloud storage under certain conditions; - Interaction with other NVC under certain conditions;
US3	Trust	Get to know the general viewpoint of users	- Must not be addictive; - A compensation for damage to health; - Contribute to help the user to eat better.	- Framework to make the user independent over time; - Pay attention to fragile people such as diabetic, ill persons in general, etc.
US4	Personal information of the user	Know the user profile	- The use of NVC for children should be restrictive	-Available in all countries; - Perform well for all genders -Adaptative to the user's education level; -Adaptive to the occupation/background

Table 4 - A summary of the survey on user expectations.

Social Requirements

Basic Principle of social requirements

A socio-technical system is a social system built upon a technical base. A socio technical system adds social requirements to human-agent interaction requirements, which already add to technical (hardware and software) requirements [4]. Socio technical performances can be applied at level of individual or at the communal level [5].

- At the human level (Figure 7c) The human terms flexibility and reliability describe the ability to change and not change given outer changes and inner changes respectively. Richness represents how much human meaning is communicated, and confidentiality lets one control one’s “image” to others. Also, part of human success is tool use, which in IT is extendibility, yet we also need security to defend against hijack attempts.
- The communal level (Figure 7d) exchanges group, community, organization or society norms, beliefs, memes and culture. People in social groups have synergy if a social unit produces more than its members would alone. A society needs privacy rules to shield members from each other and has transparency. Openness means the society lets other people and ideas enter to make value, while identity draws the conceptual boundary between “us” (the in-group) and “them” (the out-group), which written or unwritten “constitution”

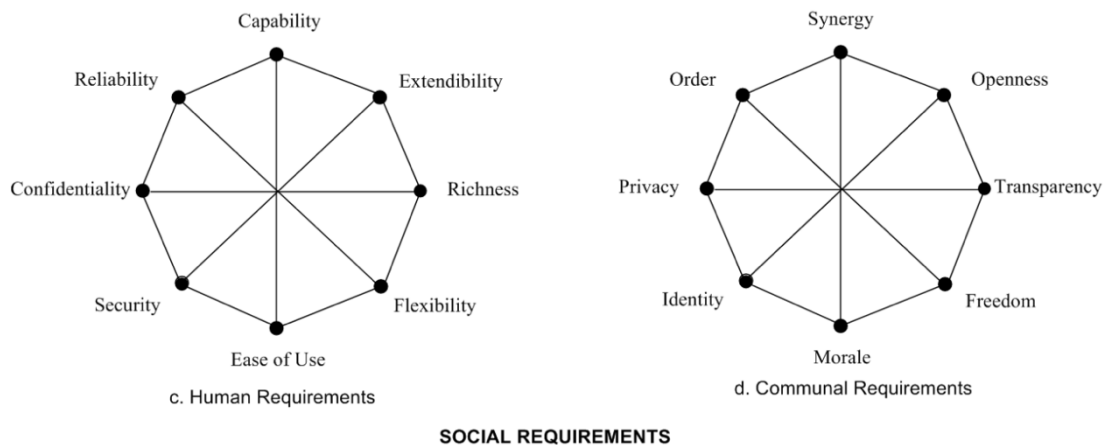


Figure 7: Some Social Requirements among others (Human Requirements and Communal Requirements) [4, 5]

Social requirement in the context of a nutritional virtual coach

In the age of digital transformation, where artificial intelligence and machine learning have become integral to our daily lives, nutritional virtual coaches (NVC) have emerged as a promising tool to guide individuals towards healthier eating habits. However, like all tech-based solutions, they come with their own set of societal implications and responsibilities. These systems,

designed to suggest dietary choices to users, are not merely about algorithms and databases. They hold a mirror to the diverse, intricate societal fabric where they operate. To ensure that our proposed system are universally beneficial and ethically grounded, certain social requirements must be prioritized.

One of the first social requirements is user privacy and data security. Users entrust NVC platforms with sensitive information, expecting discretion and protection. Alongside, it's crucial to emphasize inclusivity, ensuring the system caters to the dietary needs, cultural backgrounds, and health conditions of its audience. Furthermore, the integrity of recommendations, grounded in evidence-based research, cannot be compromised. This is closely tied to the system's responsibility to combat misinformation, which is rife in the realm of nutrition.

In a modern world, cultural sensitivity becomes paramount, recognizing and valuing diverse food traditions and norms. Moreover, the balance of power must tilt in favour of user autonomy, allowing individuals the freedom to make informed decisions without undue coercion. As we navigate the intersection of technology and nutrition, these social requirements not only enhance the utility of food recommender systems but also uphold the very essence of ethical digital innovation.

Furthermore, designing such a system, involving diverse users in the design and testing phase ensures the platform's inclusivity and effectiveness. Feedback loops, constant iteration, and user-centric design thinking are crucial. In fact, user studies are instrumental in understanding the societal requirements of a system, ensuring that it aligns with the needs and values of the broader community. Table 5 presents the social requirements considered and non-considered in the project.

ID	Title	Description		status
SR1	Privacy & Security	<ul style="list-style-type: none"> - Data encryption: employ end-to-end encryption to protect user data - Anonymous usage: allow users to utilize the platform without sharing personal data, if desired. - Transparency: clearly outline the data usage policy and gain informed consent 	Considered in the project	Ongoing
SR2	Accessibility	<ul style="list-style-type: none"> - User-friendly interface: design for all suitable age groups - Multi-lingual support: offer multiple language options and possibly regional dialects. - Voice commands & audio feedback: cater to the visually impaired by incorporating voice-activated functionalities. 	Considered in the project	Ongoing

SR3	Social Interaction Features	<ul style="list-style-type: none"> - Peer support groups: allow users to form or join groups for sharing experiences, challenges, and successes. 	Not considered in the project	Not Applicable
SR4	Cultural Sensitivity	<ul style="list-style-type: none"> - Diverse recipe database: incorporate a variety of world cuisines, ensuring authenticity and respect. - Educational blurbs: Offer information about the origin, history, or cultural significance of dishes. 	Considered in the project	Done
SR5	Feedback and Adaptability	<ul style="list-style-type: none"> - Feedback loops: allow users to rate and review recommendations received and associated explanation; use this data to refine recommendations and explanations - Adaptive: recommendations based on user behaviour and preferences. - Surveys & focus groups: periodically gather in-depth feedback to make system improvements. 	Considered in the project	Done
SR6	Diverse Dietary Needs & Preferences	<ul style="list-style-type: none"> - Allergies and intolerances: ensure that users can specify common allergies (nuts, dairy, shellfish) and the system avoids suggesting these foods. - Religious & cultural restrictions: recognize the needs of users following Halal, Kosher, Jain, or other religious dietary guidelines. - Dietary choices: address various diets like vegetarian, vegan, paleo, keto, and more. 	Considered in the project	Done
SR7	Educational Components	<ul style="list-style-type: none"> - Nutritional breakdown: provide detailed information about the nutritional value of meals. - Cooking techniques: offer video demonstrations for various cooking methods, especially for lesser-known dishes. - Health articles: Collaborate with nutritionists and dietitians to publish articles on various health topics. 	Not considered in the project	Ongoing
SR8	Emergency Protocols	<ul style="list-style-type: none"> - Health alerts: If a user reports feeling unwell due to a meal, offer 	Not considered in the project	Not applicable

		<p>immediate guidance or emergency contact suggestions.</p> <ul style="list-style-type: none"> - Allergic reaction guidance: provide first-aid information if a user suspects they've consumed an allergen. 		
SR9	Socioeconomic considerations	<p>Budget Filters: allow users to set budget constraints for meal planning.</p> <p>Local market integration: suggest recipes based on local market availability and prices.</p> <p>Zero-waste suggestions: recommend recipes that help users utilize leftover ingredients to minimize waste</p>	Not considered in the project	Not applicable

Table 5: Social requirement

Appendix 1 SURVEY TECHNICAL REPORT

INTRODUCTION

The issue of nutritional health is gaining momentum in the contemporary world; the forecasts are always in favor of a depravity of nutritional habits if nothing is done. The increase on the one hand in individuals suffering from obesity and on the other hand in children suffering from severe acute malnutrition is a witness to this problem. Excesses and deficiencies are both detrimental to health; but can be avoided by good eating habits in accordance with our needs and not just our desires. Indeed, many people eat exclusively according to their desires, thus, there is an urgent need to take their nutritional needs into account. If for some, ignorance is the cause; for others, negligence, lack of cognitive investment, discouragement after efforts with not clearly obvious results, lack of motivation or insufficient motivation, lack of follow-up, indiscipline, etc. are the causes. Another problem is knowing the nutritional value of the foods we eat, when they are raw and when they are cooked. In such a context, we really need help or better guidance from professionals in the field since most of us do not really know about it. The presence of nutritional coaches, nutritionists in hospitals and other structures has considerably allowed an involution of nutritional disorders. Their various interventions have made it possible to educate the populations, to avoid diseases of excess and deficiency, to prevent the complications of other pathologies and even to treat others. Other people are digging into books on the subject, which in itself is a very good thing. But most come up against the impossibility of having explanations of unaccepted or restrictive notions. This lack of interaction thus limits user tracking. All these solutions barely cover the target. Because the demand is much greater than the supply, hence the need to develop a broader solution adapted to contemporary technology through virtual nutritional recommendation systems.

Virtual nutritional recommendation systems are digital systems that guide users in their personal or group nutritional choices, on a punctual or permanent basis, to optimize once health, by computer. They are mainly in preventive health account. In addition, they consider the user's current health status, nutritional habits, geographical nutritional possibilities and beliefs. All this is to ensure a good follow-up with good motivation. Moreover, they do not limit themselves to providing recommendations but also providing the user with detailed explanations of them. They have the advantage of high availability, in view of access via a smartphone and any other digital means. A greater part of the population will therefore be reached.

In practice, the user is connected to an online nutritional coach or a physical nutritional coach; with which they interact. The latter gives them simple recommendations adapted to their

needs. The user has the advantage of being able to ask questions, make remarks and any other contributory intervention for better health through nutrition.

The lines above have briefly presented the general idea of the project. But we found very interesting the idea of submitting to the public an online digital form in which each Internet user can build the system using their ideas. It allowed us to assess even more the importance of the need, to realize the request, and to collect the conditions to be met to make the user's experience as pleasant as possible face-to-face of the virtual nutritional recommendation system.

This report presents observations and discusses results on this investigation conducted on public perception about virtual nutritional recommendation systems. It was conducted over a period of one month and collected 130 opinions.

MATERIALS AND METHODS

We've taken on a big mission, because of the size of the target. We need to gather opinions from people of all ages, genders, professions, occupations, races, ethnic groups and cultures, including experts in the field of nutrition in all countries. A door-to-door survey would require a lot of resources and be spread over too long a period. That's why in view of the breadth of the target to be reached by our investigations, we tied ourselves to the computer tool, via a digital questionnaire of five items. We therefore called on it resources, which enabled us to produce a digital form expressing orientations in interrogative form, enabling us to collect the opinions of Internet users. Once the form had been designed, we published a link to the form on all available platforms reaching the maximum number of people. Attached to the link was a brief explanation of the purpose and nature of the survey, concluding with an invitation to share it with other acquaintances. We therefore opted for a random mode, open to all. The online form was divided into 5 main sections, as detailed below.

Personal experience of the virtual nutritional coach system

In this first part, we challenged Internet users to describe their past experiences with a nutrition coach. We also estimated the needs that the virtual nutrition coach system would meet. In addition, we wanted to work with the users to create the best conditions for exchanges between the coach and the users. Given that we want to set up this solution to help as many people as possible adopt good nutritional habits, it goes without saying that we are concerned about their comfort with the system, so as to create a comfortable climate between web users and the platform. As the target population of our sample is very varied, it was appropriate to gather a variety of opinions. Another aspect covered by this point was the availability or accessibility of the system. Since nutrition is such an important part of our daily lives, the virtual nutrition coach system was designed to be as quickly and easily accessible as possible.

The concept of an explanation

This part constitutes what we have called the foundation of our investigation, the determining factor or, better still, the central pivot. It's the heart of our investigation, because you can't get a person to adhere to an idea without convincing them, persuading them, establishing a deep conviction within them. This condition involves the notion of explanation. Because of the diversity of Internet users, the same recommendation will not be understood, translated or interpreted in the same way from one person to another and for the same person, from one age to another, from one level of education to another. It is therefore important to provide our web users with

explanations relating to the recommendations offered to them. The very first question in this section tackles the very notion of explanation. What do Internet users imply about this notion? Next, we look at the reaction expected by web users when faced with a recommendation they don't accept or understand. Finally, in this section we wanted to find out in which direction the explanations should preferably be directed. Is it their health, their eating habits, their dietary constraints, their culture, religion, ethnicity or other?

Confidentiality

The third issue we raised in our questions concerned the confidentiality of the information stored in the system. We want to protect our customers' sensitive information with the utmost care. So, it's good for us to know our access limits to a certain level of information deemed personal or private by web users. In addition, we wanted to assess the freedom to share this information with other experts or for research purposes.

Trust

The third issue we raised in our questions concerned the confidentiality of the information stored in the system. We want to protect our customers' sensitive information with the utmost care. So, it's good for us to know our access limits to a certain level of information deemed personal or private by web users. In addition, we wanted to assess the freedom to share this information with other experts or for research purposes.

Personal information of the user

Finally, we wanted to find out who was behind each answer. So, we discreetly subjected Internet users to a final series of questions relating to their personality, including: gender, age, profession, level of education, race and place of residence. This last part reveals that, despite generational, intellectual, racial, and ethnic differences, some opinions converge.

As a bonus, a short video has been made available to the user to increase their knowledge on the concept of the virtual nutritional coach system before starting to fill in the questionnaire. An opinion is taken in account if and only if the form is filled out.

The investigations made were descriptive and retrospective. It employed direct observation techniques, targeting the entire world's population. We therefore use an inferential statistic. The inclusion criterion was to connect to the investigation site and duly complete it, with a preference for any actor in the family nutritional life. The exclusion criteria were refusal to participate in the investigation and an incompletely completed form. The interested user then completed the questionnaire themselves before submitting it. We were thus able to collect 130 opinions during a

period of one month. The remainder of this report presents observations, analyses, and interpretations of each item in the questionnaire.

RESULTS AND DISCUSSION

After a month of investigation, we identified the various completely completed forms, which numbered 130. We propose at this level to discuss the results obtained following our investigation. For each question, we will propose a mini conclusion following the analysis, before making a general conclusion for each part.

Personal experience with the virtual nutrition coach system

The first part of our form focused on the past and future experience of Internet users with the virtual nutrition coach system. The aim is to assess the quantitative and qualitative needs of Internet users. The results will enable us to provide the best response adapted to contemporary realities. It is a question of improving the experience of Internet users as much as possible. This first part allows us to understand the place of the virtual nutritional coach system in various continents.

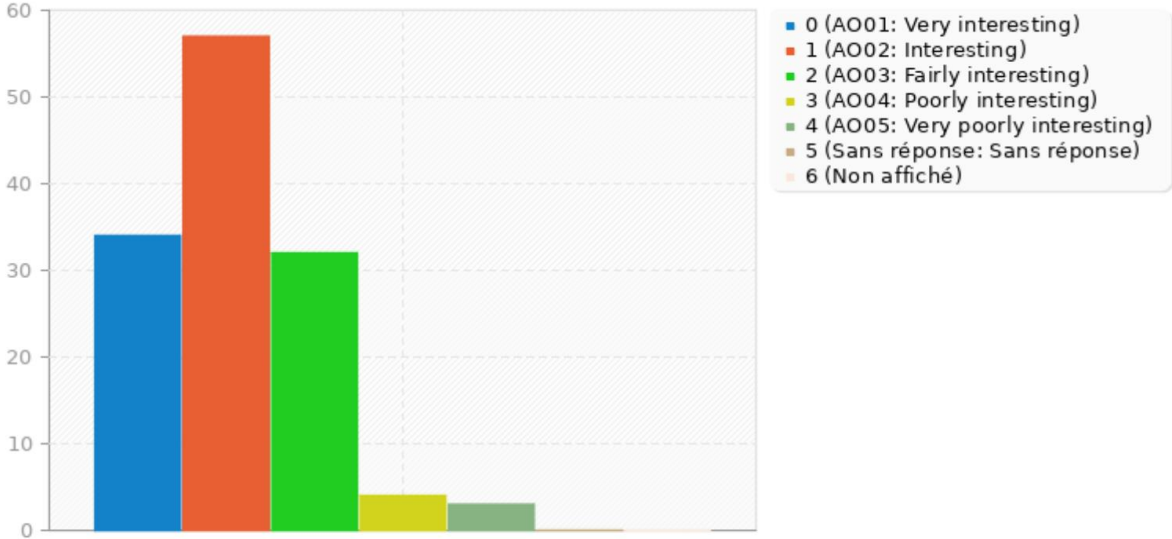
- Have you ever interacted with a nutrition virtual e-coach?

Answers	Counts	Percentages
Yes	13	10.00%
No	112	86.15%
I don't know	5	3.85%

We note from this first question that although the eating habits of the world are deteriorating and the need to change them is essential, very few people have had experience in nutritional e-coaching. Which thus gives greater importance to our study and especially to the implementation of this solution. We easily trust experts to treat us, but when it comes to preventing deficiencies and excesses through good nutrition, we make less effort. The reason for this low rate may be the subject of further investigation. For a very large number of people, it will be a new experience; all the more reason for it to be favorable. Internet users will have to open up for the first time to an opinion that is foreign to them; they will have to trust them without really knowing them. This can cause mistrust, fear, anxiety, doubt, and other feelings of opposition. This increases the interest of the next questions on the comfort of Internet users.

- How do you envision the idea of interacting with a nutrition virtual e-coach?

Answers	Counts	Percentages
Very interesting	34	26.15%
Interesting	57	43.85%
Fairly interesting	32	24.62%
Poorly interesting	4	3.08%
Very poorly interesting	3	2.31%



Although it is a new experience, the idea seems to be well received by Internet users. More than 70% of the responses are in favor of a strong interest in interacting with a nutritional e-coach. This reflects a great demand for this solution; we realize that if everyone needs to benefit from nutritional advice, digital is the best way to access homes.

The low rate (less than 6%) of responses finding the initiative not very interesting, would probably like it in person.

- Would you be prone to install a nutrition virtual e-coach app on your Smartphone?

Answers	Counts	Percentages
Yes	84	64.62%
No	24	18.46%
I don't know	22	16.92%

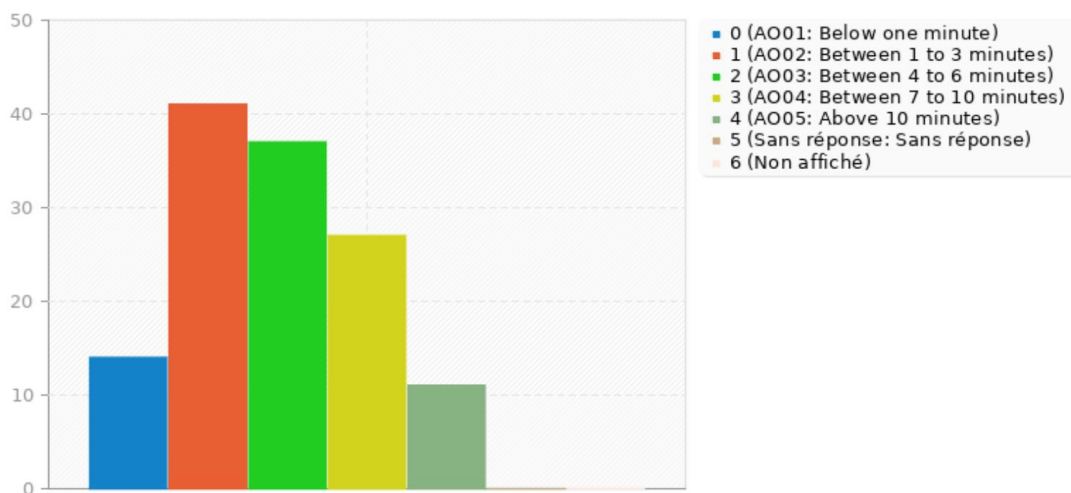
Nowadays, smartphones are the most used objects. Because of their easy mobility and the very large number of services rendered, they are always at hand. We do not

hesitate to refer to it for information. Their pocket-friendly size and easy access to the internet anywhere are other advantages of smartphones. This proximity perfectly meets the need for a nutritional e-coach system.

Internet users are willing to download a virtual nutrition coach application on their smartphones. This would increase the use of the application.

For those who are not, they will be able to have access by another less portable medium.

- Imagine that you are interacting with a nutrition virtual e-coach system, what is the maximum duration of a friendly chat?



Time is a one-way resource. They are exhausted without being able to be catch up. In a world full of distractions such as ours, any man aware of his tomorrow would pay attention to what occupies his time. The time spent on an activity reflects the importance we attach to it. If the demand is great, we notice at this level that the interviews should ideally last on average only 4.77 minutes or almost 5 minutes. This result further confirms our introductory assertions; in particular the fact that the greatest number are only very little interested in their nutrition. A convincing exchange in 5 minutes is a great challenge that the nutritional e-coach will have to take up. Except that, for certain occasions, this time will become insufficient and will have to be prolonged; this at the request of users.

- Imagine that you have to interact with a nutrition virtual e-coach system, which channels would you prefer for a such interaction?

Answers	Counts	Percentages
Web interface	26	20.00%

Mobile App	100	76.92%
Chat-bot	39	30.00%
Robot	3	2.31%
Email, SMS	20	15.38%
Other	6	4.62%

The availability of Internet users is at the center of the exchanges; their ease whatever the means is of great interest. We have committed Internet users to the responsibility of deciding for themselves the means or means that are most comfortable for them. To this multiple-choice question, the opinions turn towards an interaction via a mobile application; this supports analysis number 3.

In other, users inserted: existing IM (telegram), Mobile app with notifications from a Chat-bot, WhatsApp and Face to Face. Although this last option does not include the concept of virtual coach, it could reflect the need of some Internet users and especially the need for strict confidentiality. An advantage would therefore be to reconcile these paths in order to put each user at ease. Internet users could install the application in various media to increase their availability.

- How should the virtual nutrition e-coach react if you (the user) don't like/agree its hint/recommendation?

The system could provide advice that is contrary to or poorly adapted to beliefs, cultures, geographical circumstances of internet users but which benefits their health. How would they like the coach to react?

Answers	Counts	Percentages
No reaction	3	2.31%
Provide an explanation of the hint/recommendation	109	83.85%
Other	10	7.69%

We can see that for most opinions, a clear explanation could resolve this misunderstanding. In the other we have: provide other recommendation for the same goal; kindly try to understand and move on from there; Provide an explanation, ask if accepted, and if no, then move on; Provide an explanation and propose another hint close to the last one and ask why we didn't like or agree with the recommendation; Provide an

explanation and if I still don't agree it moves on; Suggest alternatives / explain the recommendation briefly; ask the costumer why they don't like the recommendation; Let him try to get another fill that will interest me like maybe change his method of explanation in order to convince me that what they are saying is actually the best. All in all, we realize that the opinions turn towards an explanation or an improvement of the recommendation.

This is encouraging insofar as Internet users are interested in understanding and are not limited to just wanting to move forward without conviction. This result is in favor of a good follow-up of advice.

- How should the nutrition virtual e-coach react if you (the user) don't understand its hint/recommendation?

Communication that may be misunderstood; we thought of anticipating the reaction of Internet users in such circumstances or rather, how would they like the coach to react?

Answers	Counts	Percentages
No reaction	1	0.77%
Repeat the same thing	4	3.08%
Look for other ways to explain	119	91.54%
Move on	6	4.62%

This other analysis reinforces the previous one. Our coach will therefore have to be ready to convince Internet users with a good explanation without crushing their beliefs.

When would you like to receive hints/nudges from the nutrition virtual e-coach system?

Answers	Counts	Percentages
Never	2	1.54%
Around meal-time	22	16.92%
Preventively/planned	54	41.54%
Only weekend	21	16.15%
Only weekday	4	3.08%
No matter/Always	18	13.85%
Other	9	6.92%

This electronic exchange system will modify the usual program of Internet users. They must therefore scrupulously occupy his rightful place. The ideal weather would of

course be the one that guarantees the application of the recommendations as much as possible. The hints occupy an important place in the follow up of the nutritional program; this for a change of clothes.

Observing the notices shows that these should preferably be scheduled in advance. Otherwise, they must occur around mealtimes for direct application. Only 13.85% of Internet users are willing to receive them at any time.

In other, we have: one time a day, or when the user has more struggles to follow the recommendations and need more help to make an eating habit; when asking the system; based on user's feedback; Every morning, when I wake up, I would like to receive a list of healthy food, to enjoy my day; Custom timing; While traveling; Morning, afternoon, evening per day.

An innovation would therefore be to offer the possibility to any Internet user to program the hours for the hints.

- How would you expect the nutrition virtual e-coach to motivate its hints/recommendations?

Answers	Counts	Percentages
By displaying images related to the recommendation	59	45.38%
By displaying videos related to the recommendation	41	31.54%
By adding motivations and the explanations related to the recommendation	76	58.46%
Other	3	26.92%

Motivation is at the root of any action, especially those that are prolonged over time. It also defines the ability to persevere in an instruction. It reinforces when the expected results are not yet concrete. However, not everyone finds motivation through the same channel. An image, a video, a motivating explanation or other means are offered to Internet users. These give us to understand that a recommendation will have a greater impact if it is accompanied by an explanation. Images and videos remain important accessories for diversifying learning and motivating our web users. For example, images

or videos showing concrete results of the recommendation would be more motivating than a simple theoretical explanation.

In others, we have: remind me of the benefits; By proposing a cooking recipe; By showing actual researched data.

- How would you prefer to interact with an e-coach system?

Answers	Counts	Percentages
Sole user-initiated interactions	20	15.38%
Sole virtual assistant-initiated interactions	15	11.54%
A mix of both	94	72.31%
Other	1	0.77%

Finally, to close this first part on the user experience, we wanted to collect user opinions on the mode of initiating exchanges. Although scheduled exchanges are the means chosen by users, it may happen that they forget the appointment they would have made themselves. They may also be unable to initiate the exchanges on their own, for a variety of reasons, which gives meaning to the option of the intervention of an assistant. For most web users, it doesn't matter how an interaction is initiated. An optional dual mode remains the ideal solution. In the event of a session being postponed, for one reason or another, the assistant must be informed in order to cancel the automatic initiation of the exchange.

CONCLUSION 1: At the end of this first section on the user experience of virtual nutrition coach systems, we can make the following points:

- For one reason or another, few people have been in contact with nutrition e-coaches;
- The need is great and Internet users are willing to give up their time to improve their nutritional habits for their own benefit. As long as this time is planned in advance;
- A mobile application in a smartphone remains the practical means of interaction;
- Detailed explanations, images and videos are effective ways of convincing web users who disagree or are unsatisfied with a recommendation.

Internet users will enjoy a better experience with the system if these conclusions are taken into account.

The definition of an explanation

The conclusion of the first part of this report called for good explanations to convince, encourage and motivate Internet users. The LAROUSSE dictionary defines the word explanation as being: “the action of explaining”, “the development intended to enlighten, to make people understand”, “What accounts for something”. Although this is a definition believed to be universal, not everyone accepts it as such. So, it is important to understand what internet users mean by explanation especially in nutrition virtual systems context. It is this concern that constitutes the main subject of this second part.

- In the context of nutrition virtual systems, what would an "explanation" be?

What could be more direct or elementary than starting with the definition of a notion that we wish to understand? This first open-ended question may seem awkward, but it has its place in such an investigation. We wanted Internet users to openly express their thoughts on the question. In a text field, users were invited to express write a definition of the word explanation. We have not imposed a formal definition or attached a reference; on the contrary, users had to express their understanding of the term in simple language. For this reason, we say that there is no “right” or “wrong” answer; but within the diversity of opinions, we draw a richness and edification. The program must satisfy all its users as much as possible. We remember that we have to deal with individuals of all horizons, languages, creeds, races, professions, ages and many other traits of difference. This divergence influences the nutritional choices and diets of these individuals. Although our recommendations are all oriented towards a universal nutritional health system, we wish to adapt it to the realities of the user, while retaining the choice to open up to other nutritional realities in other places. This takes on its full meaning when we have to administer the concomitant nutrition of several individuals from diverse backgrounds (during a conference, convention, retreat or seminar, an international camp for example). Moreover, medicine through good nutrition is not just a scientific field, for some peoples it is a cultural matter. That said, a misunderstood recommendation must imperatively call for a clear and convincing explanation.

To this open question, we received only 61 responses out of the 130 forms. The other forms were nevertheless always taken into account for the sole reason that it was

not a mandatory question. We present below the main ideas of the 61 responses we received. An explanation is :

- a recommendation based on national or international nutrition guidelines with some short text and references.

An explanation according to this category of people must imperatively be based on national or international guidelines. An explanation must have a scientific and non-emotional basis. Convince with proven facts and not persuasive speeches.

- Be able to make that user fully understand the recommendation and the causes that led to that. Also, what could i change to obtain a different recommendation that they like more.

The principle of "cause and effect" is a whole logical resonance used to explain facts. It is also used to predict events, to modify the facts by modifying the cause responsible for their creation. Then this category of individuals will be satisfied in front of an explanation exposing the origin / the motivation at the base of the recommendation. They also suggest using other means to achieve the same result.

- Evidence-based information, linked to relevant aspects for the user. Generic explanations may not be too useful.

This third category approaches the first; but it does not specify the reference level of this evidence-based information. Knowing that a recommendation can be subjective, it will be necessary to provide explanations on a case-by-case basis with evidence. A catalog having archived previous results will be very useful to explain recommendations.

- Say it in other ways.

The greatest number of votes was summed up in this short assertion "say it in other ways". If a wording is not understood, the easiest way is to change it to a simpler one. One could ask the listener which term is problematic in the wording, because very often just one word can change the meaning of a sentence. The coach will then find simpler terms adapted to the personality of the user.

- An explanation will be the answer to the question "why should I do that".

Finally, the last category of people made us understand that an explanation is the "why?" ". Regardless of the basis of this "why" if it is convincing, it is ideal.

What would be the best explanation then? Is there an understanding of the explanation that is universal? From the foregoing we can say that a good explanation is **that reformulation of an assertion which, by indicating its raison d'être by solid evidence recognized on acceptable scales and employing other terms than those of the initial formulation, removes any ambiguity.**

Now that we know what an explanation is, we are concerned with knowing the reaction of Internet users to explanations advocating a particular interest.

- Imagine that a nutrition virtual system provides an explanation to support its recommendations. What would you expect? Mostly if the explanation is linked to:

- **Your health**

Answers	Counts	Percentages
Very Important	89	68.46%
Important	33	25.38%
Moderately Important	6	4.62%
Slightly Important	1	0.77%
Unimportant	1	0.77%

An explanation of the health benefits, together with a recommendation, would be greatly appreciated by Internet users. That's what 93.84% of people think. This puts this orientation in the first position. As might be expected from previous analysis. As better health being the main purpose of the virtual nutrition coach system, explanations should be geared towards this area. For others, however, the health motive remains insufficient.

- **Your food choices criteria**

Answers	Counts	Percentages
Very Important	56	43.08%
Important	57	43.85%
Moderately Important	14	10.77%
Slightly Important	2	1.54%
Unimportant	1	0.77%

Beyond the health interest of our recommendations, we must take into account the user's food choice criteria. This is what 86.93% of the people who participated in our investigation think.

○ **Your food constraints**

Answers	Counts	Percentages
Very Important	59	45.38%
Important	52	40.00%
Moderately Important	16	12.31%
Slightly Important	2	1.54%
Unimportant	1	0.77%

Nutritional constraints also constitute a significant limitation in the follow-up of interviews. The coach must therefore provide explanations on this subject to help remove these constraints as far as possible. So it is not enough to offer a meal, but also to be reassured that the ingredients of this meal are within reach of users. At worst, offer substitutes for unavailable ingredients. This agrees with the thoughts of 85.38% of people.

○ **Your eating habit**

Answers	Counts	Percentages
Very Important	51	39.23%
Important	47	36.15%
Moderately Important	23	17.69%
Slightly Important	9	6.92%
Unimportant	0	0.00%

As previous nutritional habits are challenged by the nutrition coach's new recommendations, the coach will undoubtedly have to argue in comparison with old habits, by way of contrast. However, it should be noted that the importance of this orientation in the explanations is judged slightly less important than previous orientations. Indeed, here it is the opinion of 75.38% of people.

○ **Your religious requirements**

Answers	Counts	Percentages
Very Important	35	26.92%

Important	24	18.46%
Moderately Important	24	18.46%
Slightly Important	19	14.62%
Unimportant	28	21.54%

It is very important to take into consideration the religious beliefs of the users. Indeed, some religions prohibit certain foods, others attach good or bad facts. This is for example the case of the Muslim religion which prohibits the consumption of pork. Although it is important to provide clarification on this area, Internet users find this orientation less important than the others. Religious guidance comes up against genuine reluctance. It should only be used in case of great necessity. The percentage of opinions finding this orientation important is only 45.38%, less than half of the individuals who answered this question. Also, the percentage of those who find this orientation not important is not negligible, because amounting to 21.54%.

- o **Your cultural, ethnics, racial and societal background**

Answers	Counts	Percentages
Very Important	27	20.77%
Important	24	18.46%
Moderately Important	29	22.31%
Slightly Important	23	17.69%
Unimportant	27	20.77%

Just like religious orientation, cultural, ethnic, racial, and social background is not a very useful medium for explaining recommendations. It is the last ranked according to our investigation, because only 39.23% find it important.

After the question of orientation, comes that of the support to be used in order to be able to provide a good explanation. Indeed, one of the definitions of explanation, as we saw at the start of this second part, is the use of other terms or other means. The next question offered a multiple choice to Internet users on the most appropriate choice that the coach should use to explain a recommendation.

The next tables present in turn the opinion of Internet users on various means. These means correspond to the means deemed useful for learning. Some appeal to just one meaning, others to more than one.

- What mediums would you expect from an explanation provided by a nutrition e-coaching system?

- **Text**

Answers	Counts	Percentages
Very Important	56	43.08%
Important	51	39.23%
Moderately Important	18	13.85%
Slightly Important	5	3.85%
Unimportant	0	0.00%

- **Pictures**

Answers	Counts	Percentages
Very Important	50	38.46%
Important	53	40.77%
Moderately Important	19	14.62%
Slightly Important	6	4.62%
Unimportant	02	1.54%

- **Schemas**

Answers	Counts	Percentages
Very Important	38	29.23%
Important	46	35.38%
Moderately Important	29	22.31%
Slightly Important	13	10.00%
Unimportant	04	3.08%

- **Audio**

Answers	Counts	Percentages
Very Important	29	22.31%
Important	32	24.62%
Moderately Important	24	18.46%
Slightly Important	25	19.23%

Unimportant	20	15.38%
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- **Video**

Answers	Counts	Percentages
Very Important	36	27.69%
Important	34	26.15%
Moderately Important	26	20.00%
Slightly Important	19	14.62%
Unimportant	15	11.54%

From these 5 statistical tables, presenting the appreciation of Internet users for a different explanatory medium (text, image, diagram, sound or video), we note that: a simple text explanation outweighs all other media; this with 82.31%. This text should ideally be an article or evidence-bases to reinforce the recommendations. The use of images takes second place in this ranking. These options could boost the five minutes of interaction. Internet users could thus benefit from the literature to be read at the end of each session.

Following the favorable means to be used for an explanation, the question of frequency arises. It would be necessary to establish a good balance between recommendation and explanation because the coach will preferably only have 5 minutes to exhort the users.

- How often should a nutrition e-coaching system try to explain its suggestions/recommendations?

Answers	Counts	Percentages
Always	33	25.38%
Very often	64	49.23%
Sometimes	30	23.08%
Rarely	03	2.31%
Never	00	0.00%

- How often would you like a nutrition e-coaching system to explain its suggestions/recommendations in an iterative interaction?

Answers	Counts	Percentages
Always	30	23.08%
Very often	45	34.62%
Sometimes	45	34.62%
Rarely	10	7.69%
Never	00	0.00%

We agree on the important role that explanations play in exchanges. However, exchanges full of explanations would reflect a poor understanding of the user's personality. It would be not having properly integrated the information defining the user. So the explanations will have to intervene as long as necessary.

CONCLUSION 2: Having reached the end of this second section on the notion of explanation, we can retain the following points:

- In such a system, explanation has a key role to play in establishing convictions;
- An explanation is additional information that uses a different formula from the basic information, based on solid references or foundations, enabling the web user to understand the importance, advantages, limits and scope of a recommendation;
- It should preferably be related to the surfer's health. But it should also reveal the scope of food choices criteria, food constraints and eating habits; religious, cultural, ethnic and other orientations remain secondary but not negligible;
- Text, with or without images, remains the most popular means of conveying explanations. These should be used as often as necessary.

- Privacy/ confidentiality

The virtual nutrition coach system will involve the sharing of potentially sensitive information which, in the wrong hands, could harm the lives of our web users. Like any self-respecting platform, we thought it would be a good idea to ask questions about the confidentiality of shared information. It is also a way for us to engage users in confidentiality clauses that they would have defined themselves.

- What would your main concerns be about the use/share of your personal information?

Answers	Counts	Percentages
Lack of anonymization	57	43.85%
Lack of control	32	24.62%
Third-parties access	76	58.46%
Risk outweigh benefits	28	21.54%
Concern over data use	49	37.69%
Lack of understanding about data use	36	27.69%
Other	03	2.31%

Third-party access is the primary concern of Internet users when it comes to using or sharing their information. Third-party access should therefore be avoided at all costs; at least as far as possible. Anonymity should also be used to avoid linking information to Internet users in the event of leakage or loss.

- Which kind of information are you be willing to share with your nutrition e-coach system?

Answer	Count	Percentage
Personal information	34	26.15%
Food constraints	98	75.38%
Food preferences	112	86.15%
Eating behavior	92	70.77%
Allergies and health data	90	69.23%

Diet history (retrospective dietary details of foods)	67	51.54%
Mood of current data preferences	39	30.00%
Cultural data	38	29.23%
Region data	36	27.69%
Other	04	3.08%

In response to this multiple-choice question on the kind of information that web users are willing to share with their nutrition e-coach system, opinions tended to focus on information on Food preferences, Food constraints, Eating behavior and Allergies and health data, each with a percentage above 60. The exchanges should therefore be structured around these points.

- When is the most suitable time to collect the data you may want to share with your nutrition virtual e-coach?

Answer	Count	Percentage
Never	31	23.85%
When starting to use the system	57	43.85%
At the moment of need	38	29.23%
Whenever	04	3.08%

The most appropriate time to collect the data users wish to share with their virtual nutrition e-coach is when starting to use the system. This in itself is advantageous for the e-coach, who will be able to start from a precise foundation and not grope his way forward. Another ideal time is that in case of need. The information will act as a key opening the door to new perspectives and directions, provided they are given at the right time.

Even so, we note that a high proportion of respondents answered Never. The right to remain silent must be respected.

- Who should be able to access/use the data generated by interacting with the nutrition e-coaching system?

Answers	Counts	Percentages
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Only the system	25	19.23%
The system and the designers of the system	08	6.15%
The system and the doctors	61	46.92%
The system, the doctors and the designers of the system	34	26.15%
Other	02	1.54%

This comment shows that medical advice is desirable. Internet users are willing to share their information with all the major players in the system, as long as they contribute to improving their well-being and experience with the system.

- With whom would you agree to share your anonymized data concerning your diet?

Answers	Counts	Percentages
Nobody	12	9.23%
Your nutrition virtual coach only	56	43.08%
Your nutrition virtual coach and others nutrition virtual coaches connected to yours	48	36.92%
Your nutrition virtual coach and any third parties	11	8.46%
Other	03	2.31%

Apart from the additional medical advice, a second opinion from other virtual coaches is also tolerated by Internet users. Some even want a third party to use it for research purposes; but this latter possibility remains an option that the system will have to make available to users.

- Who could be allowed to have access to a nutrition virtual e-coach system?

Answers	Counts	Percentages
Children	19	14.62%
Teenagers	69	53.08%
Adults	115	88.46%

Old people	86	66.15%
Other	10	7.69%

To round off this section, we have asked Internet users who should be allowed access to the nutrition virtual e-coach system. It was a multiple-choice question, with adults in first place followed by the elderly and young people in third place. This choice is undoubtedly motivated by the fact that they are the major players influencing the nutritional life of the family.

CONCLUSION 3: At the end of this third part, we note that :

- The confidentiality plays an important role in the safety and well-being of users;
- The exchanges should focus primarily on nutritional preferences, and their content and their content could be shared with other coaches or health professionals;
- The personal information should be collected at the beginning of interactions, if not when needed.
- The major players influencing the nutritional life of families or homes being adults, young people and the elderly, they are the target of the system.

- Trust

Beliefs are the main motivators behind our actions. Many things are said around us about the world, and without us often realizing it, these popular beliefs influence our actions. Cultures, religions, ethnic groups and other moral convictions form the basis of our beliefs. What do Internet users think about the e-coach nutrition system?

- Do you think that nutritional virtual coach systems might instill dependency in its users?

Answer	Count	Percentage
Definitively	19	14.62%
Very Probably	30	23.08%
Probably	58	44.62%
Probably Not	19	14.62%
Definitively not	04	3.08%

The contemporary digital world is the subject of accusations. It is accused of creating dependency in its users. So it's legitimate for us to be concerned. Opinions are divided, but the majority are leaning towards a probable risk of producing dependency in these users. The system will therefore have to employ strategies to make users as independent as possible, hence the questions of personal conviction.

- What would increase your trust in recommendations/suggestions/explanations provided by a virtual coaching system?

Answers	Counts	Percentages
The explanations of the e-coach	73	56.15%
Your personal experience if any	69	53.08%
The advice from a relative	24	18.46%
The score of other users based on their experiences	46	35.38%
Other	06	4.62%

A recommendation is effective and convincing if it is associated with an explanation or if it corroborates personal experience. In any case, it should be as close as possible to users' realities.

- Would you accept/trust recommendations/suggestions/explanations attained by mixing your anonymized data with other users' anonymized data?

Answers	Counts	Percentages
Strongly accept	10	7.69%
Accept	70	53.85%
Undecided	32	24.62%
Reject	08	6.15%
Strongly reject	10	7.69%

We have no objection to the crossing of anonymous user information, with the aim of establishing a deeper conviction. Here's an option that will satisfy our users passionate by numbers.

- Who would you hold the most accountable if the e-coach provided you with an incorrect/suboptimal recommendation that could compromise your health goal?

Answers	Counts	Percentages
Nobody	04	3.08%
Only the system	27	20.77%
The system, the nutrition specialists and the doctors	47	36.15%
The system, the engineers and researchers	34	26.15%
Everybody	14	10.77%
Other	04	3.08%

Users accept no responsibility for any adverse consequences arising from incorrect information, which they pass on to the system operators.

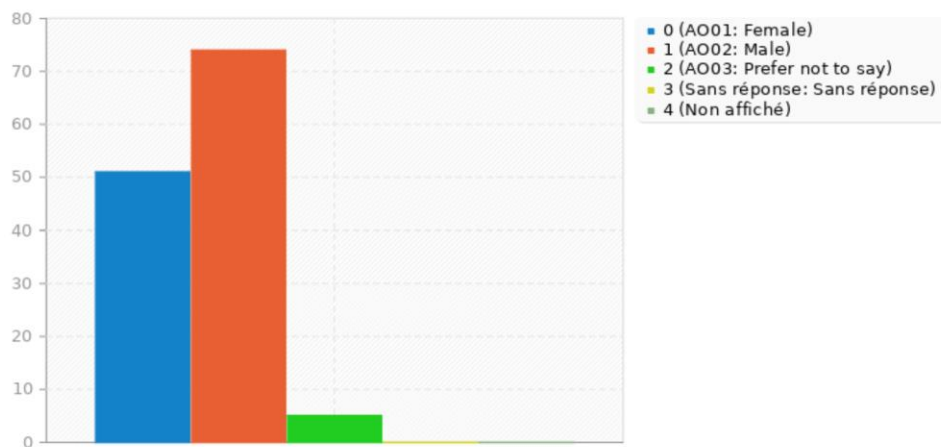
CONCLUSION 4: Successful implementation of e-coach recommendations by users depends on their belief in them. To boost this belief, the following elements can be used:

- Explanations in line with the analysis in Part 2;
- Crossing of anonymous user information.
- The system must be responsible for all the recommendations it will produce.
- Personal information of the user

At this point, let's look at the user profile.

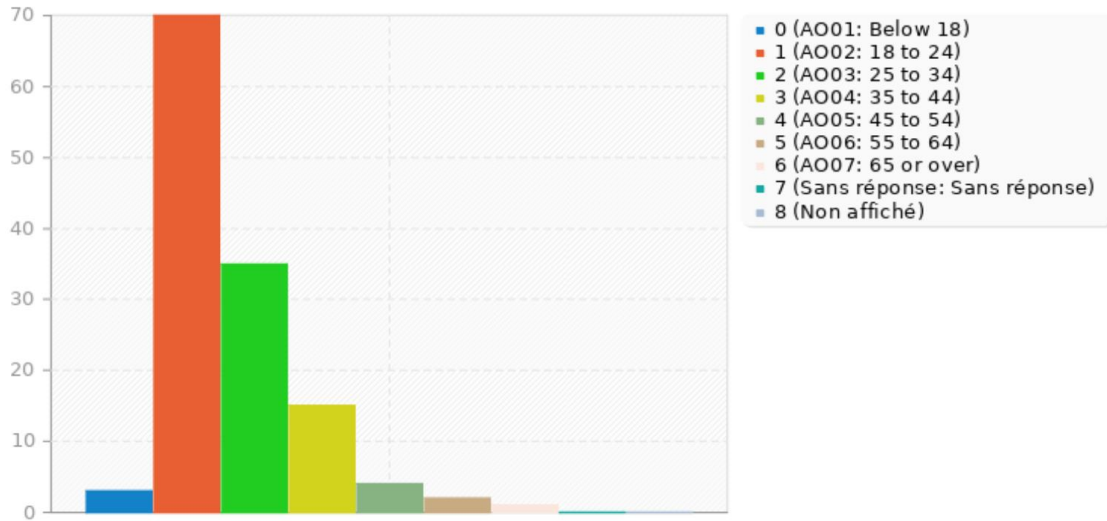
- What is your gender?

Answers	Counts	Percentages
Female	51	39.23%
Male	74	56.92%
Prefer not to say	05	3.85%



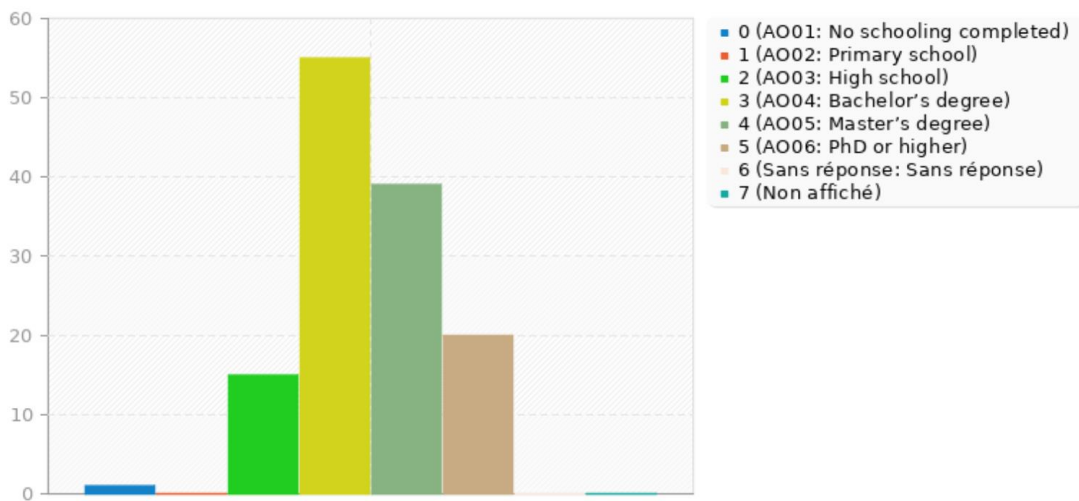
- What is your age ?

Answers	Counts	Percentages
Below	03	2.31%
18 to 24	70	53.85%
25 to 34	35	26.92%
35 to 44	15	11.54%
45 to 54	04	3.08%
55 to 64	02	1.54%
65 or over	01	0.77%



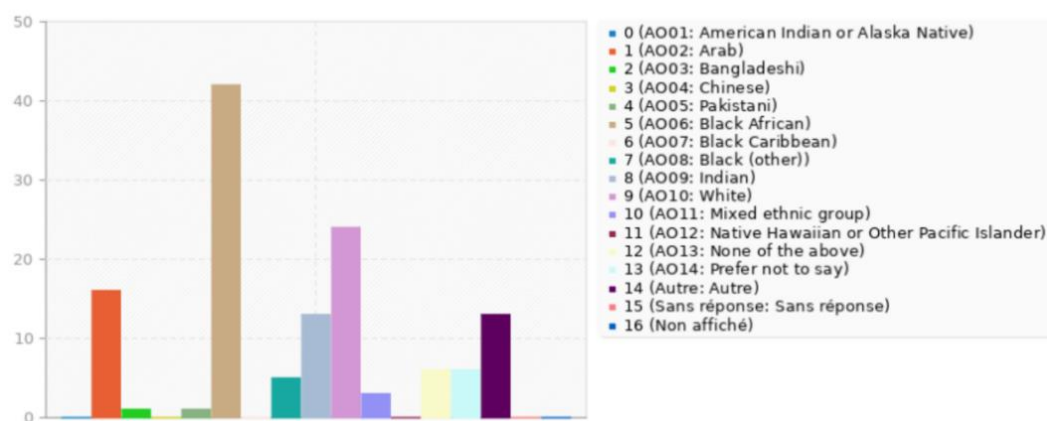
- What is your level of education?

Answers	Counts	Percentages
No schooling completed	01	0.77%
Primary school	00	0.00%
High school	15	11.54%
Bachelor's degree	55	42.31%
Master's degree	39	30.00%
PhD or higher	20	15.38%



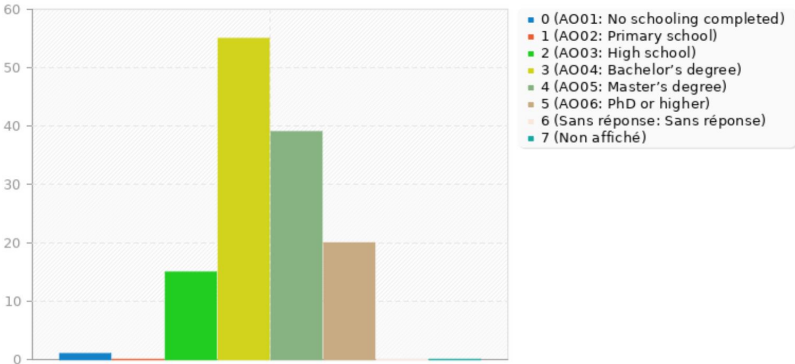
- How would you best describe yourself?

Answers	Counts	Percentages
American Indian or Alaska Native	00	3.08%
Arab	16	0.00%
Bangladeshi	01	12.31%
Chinese	00	0.77%
Pakistani	01	0.00%
Black African	42	0.77%
Black Caribbean	00	32.31%
Black (other)	05	0.00%
Indian	13	3.85%
White	24	10.00%
Mixed ethnic group	03	18.46%
Native Hawaiian or Other Pacific Islander	00	2.31%
None of the above	06	0.00%
Prefer not to say	06	4.62%
Other	13	4.62%



- Where is your home located (where do you live) ?

Answers	Counts	Percentages
North America/Central America	01	0.77%
South America	02	1.54%
Europe	37	28.46%
Africa	69	53.08%
Asia	11	8.46%
Australia	00	0.00%
Caribbean Islands	00	0.00%
Pacific Islands	00	0.00%
Other	10	7.69%



- What is your work industry?

Answers	Counts	Percentages
Agriculture	02	1.54%
Utilities	02	1.54%
Finance	06	4.62%
Entertainment	02	1.54%
Education	34	26.15%
Health care	08	6.15%
Information services	15	11.54%
Data processing	12	9.23%
Food services	00	0.00%
Hotel services	00	0.00%

Legal services	00	0.00%
Publishing	00	0.00%
Military	00	0.00%
Prefer not to say	17	13.08%
Other	32	24.62%

In other, we have: No work; arts; administration; oil and gas as complementary answers.

- In a normal week, how often do you prepare and cook a main meal from basic ingredients?

Answers	Counts	Percentages
Never	12	9.23%
Less than once a week	16	12.31%
Once a week	09	6.92%
2-3 times a week	47	36.15%
4-6 times a week	16	12.31%
Daily	30	23.08%

CONCLUSION AND OUTLOOK TIVES

In conclusion, the ever-increasing prevalence of metabolic diseases due to poor diet or poorly controlled eating habits means that everyone needs to be educated about good nutritional habits. These can not only prevent the onset of disease, but also reduce the impact of other illnesses, and even prevent complications from other pathologies. There's a wise saying: "Let your food be your medicine, and your medicine your food".

The creation of a virtual nutrition coach system would meet this need. The system is aimed primarily at those involved in the nutritional life of the home. It is intended to be confidential, explanatory and adapted to the users' comfort level, taking into account their health, nutritional habits, constraints and beliefs.

Thanks to this virtual coaching system, many homes will be able to improve their nutrition for the benefit of their health. On a global scale, this will contribute to a considerable reduction in pathologies caused by poor nutrition. A future project will see this system linked to a food market capable of home delivery. In addition to

recommendations and recipes, users will be able to receive ready-made meals or fresh food for cooking.

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