Klepio - Dental Care That's Always One Step Ahead

Prepared by:

Aniketh Vijesh [AM.EN.U4AIE22009]

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1. Introduction

1.1 Purpose

Klepio is an innovative web-based application meticulously designed to revolutionise the initial assessment of dental problems. Its core purpose is to empower users with an accessible, AI-driven questionnaire that intelligently guides them through a series of symptom-related inquiries. By leveraging cutting-edge artificial intelligence, Klepio aims to provide highly accurate preliminary predictions of potential dental conditions based on the user's inputs. This not only offers immediate insights to patients but also significantly streamlines and enhances the communication flow between patients and dental professionals. The system is engineered to serve as a crucial diagnostic assistant, bridging the gap between a patient's initial concerns and a doctor's informed consultation, thereby optimising the diagnostic process and ultimately contributing to more timely and effective dental care. This document meticulously details all the functional and non-functional requirements essential for the robust development, seamless deployment, and efficient operation of the Klepio application.

The advent of Klepio addresses a critical need in modern healthcare: the efficient and early identification of potential health issues, specifically within the dental domain. Traditional methods often involve lengthy waiting times for appointments and can sometimes lead to delayed diagnoses. Klepio mitigates these challenges by offering an immediate, preliminary assessment that users can conduct at their convenience. The AI's ability to process complex symptom patterns and correlate them with a vast dataset of dental conditions ensures that the predictions are not only accurate but also highly relevant to the user's specific inputs. This intelligent pre-screening capability is designed to reduce unnecessary clinic visits for minor issues while simultaneously flagging more serious concerns that warrant immediate professional attention. Ultimately, Klepio fosters a proactive approach to dental health, enabling users to take a more informed role in their well-being and facilitating a more focused and productive interaction when they do consult with a dental professional.

1.2 Document Conventions

In crafting this SRS document for Klepio, adherence to specific standards and typographical conventions has been diligently maintained to enhance clarity and facilitate effective communication. Some notable conventions include:

- **Prioritisation Hierarchy:** The document follows a standardised prioritisation system, with higher-level requirements implicitly indicating priority for associated detailed requirements.
- **Formatting for Emphasis:** Consistent formatting, including **bold**, *italics*, or `underlining` (where applicable), is used to highlight key points and critical information.
- **Section Headings and Numbering:** Clear, hierarchical section headings and a systematic numbering scheme provide a structured framework for easy navigation and reference.

- **Consistent Font and Typeface:** A uniform font and typeface ensure a professional and cohesive presentation for enhanced readability.

1.3 Intended Audience and Reading Suggestions

This document is intended for a diverse audience involved in the Klepio project. The suggested reading sequence ensures that each group gains the most relevant information tailored to their roles and responsibilities:

1. **Developers:**
2. **Project Managers:**
3. **Marketing Staff**
4. **Users:**
5. **Testers: Documentation Writers:**

1.4 Scope

The scope of Klepio encompasses providing a comprehensive and intuitive platform where patients can independently assess their dental health from the comfort of their homes. The system is designed to capture detailed symptom information through its intelligent questionnaire and process this data using its integrated AI model to generate insightful, preliminary diagnoses. For dental professionals, Klepio will serve as an invaluable tool, offering pre-analysed patient responses and AI-generated predictions, which can significantly enrich their understanding prior to a physical examination. A paramount focus of this project is to ensure the system's user-friendliness, making it accessible to individuals with varying levels of technical proficiency. The questionnaire will be meticulously crafted to be comprehensive, ensuring that a wide array of symptoms and potential conditions are covered, leading to more reliable diagnostic support. Furthermore, to cater to a diverse global user base, the application is committed to supporting multilingual accessibility, allowing users to interact with the system in their preferred language. Looking ahead, future updates will include the capability to generate and provide detailed PDF reports of the diagnosis, offering a tangible record for patients and facilitating easier sharing with their healthcare providers.

The platform's comprehensive nature extends beyond mere symptom collection; it aims to guide users through a structured diagnostic journey, ensuring that all relevant information is gathered systematically. The integration of the AI model is central to this process, transforming raw symptom data into actionable preliminary diagnoses, which can then be reviewed and confirmed by medical experts. For dental professionals, this pre-analysis capability means less time spent on initial information gathering and more time dedicated to targeted examinations and treatment planning. The commitment to user-friendliness translates into a clean, uncluttered interface with clear instructions and intuitive navigation, minimising any potential barriers to access or understanding. The multilingual support is crucial for global reach, ensuring that language does not become an impediment to accessing vital dental health information. The inclusion of PDF report generation further enhances the utility of Klepio, providing a standardised, easily shareable summary of the

assessment, which can be seamlessly integrated into patient records or shared with other healthcare providers for collaborative care.

1.5 System Requirements for Optimal Performance

To ensure the Klepio application delivers its intended functionality and optimal user experience, certain system requirements are essential for end-users. Adherence to these specifications will guarantee compatibility, stability, and access to the latest features and security updates.

- **Web Browser Compatibility:** Users are required to access Klepio via a modern, up-to-date web browser. Supported browsers include, but are not limited to, the latest stable versions of Google Chrome, Mozilla Firefox, Microsoft Edge, and Apple Safari. Using outdated browsers may result in degraded performance, display issues, or security vulnerabilities. It is highly recommended that users enable automatic updates for their chosen browser to ensure continuous compatibility and security.
- **Frontend Framework:** The Klepio user interface is built leveraging the React.js framework. For seamless interaction and to benefit from the latest features, performance enhancements, and security patches, the client-side environment implicitly requires compatibility with React.js versions that are actively supported and maintained. While users do not directly manage React.js versions, their browser's JavaScript engine must be capable of executing modern JavaScript syntax.
- **Backend Framework:** The core logic and AI model integration of Klepio are powered by a Django-based backend. While this is server-side, it implies that the application's functionality relies on a robust and secure backend infrastructure. For developers and administrators, maintaining the latest stable version of Django is crucial for security, performance, and access to new features.
- **Internet Connectivity:** A stable and reliable internet connection with a minimum recommended speed of 5 Mbps is necessary for efficient data transfer, including questionnaire submissions and receiving AI-generated diagnoses. While Klepio is designed to be lightweight, a consistent connection is vital for real-time interactions and data synchronisation.

2. Overall Description

2.1 Product Perspective

Klepio is an independent web-based system designed as a standalone dental diagnostic assistant. It interacts primarily with users and a proprietary AI model, analysing questionnaire responses to provide preliminary dental diagnoses. Crucially, Klepio is a supportive tool, not a replacement for professional medical advice, aiming to enhance patient-doctor communication and streamline the diagnostic process. Its independence ensures maximum accessibility and rapid deployment, allowing for quick iterations and AI model advancements without complex integrations.

The system's architecture emphasises modularity and open API principles for future integration with healthcare platforms. Klepio's responsibility is clearly defined: gathering symptom data, processing it via AI, and presenting a preliminary diagnosis. The final diagnosis and treatment remain with qualified dental professionals, ensuring ethical operation and patient safety. This clear delineation of roles, coupled with a focus on scalability and cloud-based infrastructure, ensures consistent performance as the user base grows.

User interaction with Klepio is intuitive and self-guided, starting with a dynamic questionnaire that securely transmits responses to the backend for AI processing. The AI's preliminary diagnosis is then presented clearly, always emphasizing its preliminary nature and recommending professional dental advice. For doctors, a secure portal offers access to patient data and AI findings, streamlining pre-consultation review and enabling more focused examinations. Data security and privacy are paramount, adhering strictly to regulations.

Klepio also aims to foster dental awareness and proactive health management. By providing accessible self-assessment, it encourages early detection and improved oral hygiene. The AI model undergoes continuous learning and validation by dental professionals, ensuring improved diagnostic accuracy. User-centric design, with a clean, responsive interface, maximises accessibility across all devices, making Klepio an approachable and trusted companion in dental health management.

2.2 Product Functions

Klepio's core functionality is segmented into several key product functions, each meticulously designed to contribute to its overarching purpose of providing an AI-driven dental diagnostic assistant. These functions work in concert to deliver a seamless and valuable experience for both patients and dental professionals.

1. **Patient Self-Assessment:** This is the primary user-facing function, enabling individuals to actively participate in their preliminary dental health diagnosis.
    - **Dynamic Questionnaire Provision:** The system must present a series of questions to the user, designed to elicit detailed information about their dental symptoms, medical history, and lifestyle factors relevant to oral health. This questionnaire is not static; it is dynamic and adaptive, meaning subsequent questions can change based on previous answers, allowing for a more targeted and efficient data collection process. For example, if a user reports tooth pain, follow-up questions might delve into the type of pain (sharp, dull, throbbing), its duration, and aggravating factors. This ensures that only relevant information is gathered, reducing user fatigue and improving data quality for the AI.
    - **Intuitive Input Mechanism:** Users must be able to easily input their responses through a variety of intuitive mechanisms, including text fields, multiple-choice selections, radio buttons, and possibly visual aids (e.g., diagrams where users can pinpoint areas of pain). The interface for this function will be clean, uncluttered, and highly responsive across various devices, ensuring accessibility for users with minimal technical expertise.

Real-time validation of inputs will guide users and prevent erroneous data entry.
    - **Progress Tracking:** To enhance the user experience, the system will provide clear indicators of progress through the questionnaire (e.g., "Question 5 of 20," or a progress bar). This helps manage user expectations and encourages completion.
2. **AI-Based Diagnosis:** This function represents the intelligent core of Klepio, processing the collected patient data to generate preliminary diagnostic insights.
    - **Advanced AI Model Integration:** The system will seamlessly integrate with a sophisticated Python-based AI model, which is the engine for processing the patient's questionnaire responses. This model will be trained on an extensive, high-quality dataset comprising a wide variety of dental conditions (currently targeting 28 distinct conditions, with future expansion planned), associated symptoms, and confirmed diagnoses. The training data will be meticulously curated and validated by experienced dental professionals to ensure the model's accuracy and reliability.
    - **Symptom-to-Diagnosis Mapping:** The AI model will employ advanced machine learning algorithms (e.g., classification, pattern recognition) to analyze the complex interplay of reported symptoms, medical history, and other relevant factors. It will then map these inputs to potential dental conditions, generating a predicted diagnosis or a set of most probable diagnoses. The output will include a confidence score or probability for each predicted condition, indicating the AI's certainty.
    - **Clear and Concise Output:** The AI-generated diagnosis results must be presented to the patient in a clear, concise, and easily understandable language, avoiding overly technical jargon. While providing initial insights, the output will consistently emphasize that this is a preliminary assessment and does not substitute for a professional dental examination. It will also include actionable advice, such as "consult a dentist within 24 hours" for urgent cases, or "monitor symptoms and schedule a routine check-up" for less severe concerns.
3. **Doctor's Access:** This function provides a secure and specialized interface for dental professionals to review and utilize the patient-generated data and AI insights.
    - **Secure Patient Data Review:** Doctors will have access to a secure, authenticated portal where they can view a comprehensive summary of their patients' self-assessment responses. This includes all answers provided in the questionnaire, along with the raw data. This allows for a thorough understanding of the patient's reported symptoms before a physical consultation.
    - **AI Prediction Verification:** The portal will display the AI-generated preliminary diagnoses, including the confidence scores. This allows doctors to quickly grasp the AI's assessment and use it as a starting point for their own diagnostic process. Doctors can verify, override, or refine the AI's predictions based on their clinical judgment and further examination.
    - **Note-Taking and Consultation Summary:** The system will provide functionalities for doctors to add their own clinical notes, observations, and confirmed diagnoses directly within the patient's record on the Klepio platform. This feature facilitates a comprehensive record of the consultation

and can be integrated into the patient's overall dental health profile within Klepio.

4. **User-Friendly Interface:** This overarching function ensures that the entire Klepio application is intuitive, accessible, and provides a positive user experience for all user classes.
    - **Simplicity and Ease of Use:** The application's design philosophy prioritizes simplicity and ease of use. Navigation will be intuitive, with clear labels, logical flow, and minimal steps required to complete tasks. The visual design will be clean and uncluttered, reducing cognitive load.
    - **Responsive Design:** The UI will be fully responsive, adapting seamlessly to various screen sizes and orientations, from large desktop monitors to tablets and smartphones. This ensures consistent usability and accessibility across a wide range of devices without compromising functionality or aesthetics.
    - **Accessibility Features:** Adherence to web accessibility standards (e.g., WCAG guidelines) will be a priority, including features like keyboard navigation, sufficient color contrast, and screen reader compatibility, to ensure the application is usable by individuals with diverse needs.
5. **PDF Report Generation (Future Feature):** While not part of the initial release, this is a planned enhancement to provide tangible, shareable summaries of the diagnostic process.
    - **On-Demand Report Creation:** Users will have the option to generate and download a comprehensive PDF report of their self-assessment and the AI's preliminary diagnosis. This report will include a summary of symptoms, the AI's predicted conditions, and disclaimers about the preliminary nature of the diagnosis.
    - **Professional Formatting:** The PDF reports will be professionally formatted, suitable for printing or digital sharing with dental professionals, ensuring clarity and readability. This feature will enhance the utility of Klepio as a personal health record tool.

3. Specific Requirements

This section details the specific functional and non-functional requirements for the Klepio application. Functional requirements describe what the system must do, while non-functional requirements specify how well the system must perform these functions.

3.1 Functional Requirements

Functional requirements define the core behaviors and capabilities that Klepio must possess to fulfill its purpose.

3.1.1 Patient Self-Assessment

This foundational feature enables users to interact directly with Klepio to provide their symptoms and relevant health information.

- **Intuitive and Adaptive Questionnaire Provision:** The system must provide a highly intuitive, dynamic, and adaptive questionnaire for patients to input their symptoms. This means the flow of questions will intelligently adjust based on previous user responses, ensuring that only relevant follow-up questions are presented. For instance, if a user indicates "tooth pain," subsequent questions might dynamically appear to inquire about the specific location of the pain (e.g., upper left molar), its character (e.g., sharp, dull, throbbing), its duration (e.g., constant, intermittent), and aggravating or relieving factors (e.g., sensitivity to hot/cold, chewing). This adaptive logic minimizes irrelevant questions, reduces user fatigue, and ensures comprehensive data collection for the AI model. The questionnaire will support various input types, including multiple-choice selections, radio buttons, free-text fields for detailed descriptions, and potentially interactive anatomical diagrams where users can visually pinpoint areas of concern.
- **Real-time Input Validation and Guidance:** As users complete the questionnaire, the system must provide real-time validation of their inputs. This includes immediate feedback for missing required fields, format errors (e.g., invalid date entry), or logical inconsistencies. Clear, user-friendly messages will guide patients to correct their entries. Additionally, context-sensitive tooltips or brief explanations will be available for medical terms or complex questions, ensuring that users understand what information is being requested and can provide accurate responses. This proactive guidance minimizes errors and improves the quality of data fed into the AI.
- **User Profile and Session Management:** For returning users, the system must allow for the creation and management of a secure user profile. This profile will store basic demographic information and, with user consent, previous assessment history. The system must also support session persistence, allowing users to pause and resume their self-assessment sessions without losing progress, enhancing convenience and reducing potential frustration. All profile data will be encrypted and stored securely, adhering to privacy regulations.

3.1.2 AI-Based Diagnosis

This is the central intelligence of Klepio, responsible for processing patient data and generating preliminary diagnostic insights.

- **Robust AI Model Training and Integration:** The AI model, primarily developed using Python and integrated via a REST API, must be trained on an extensive and meticulously curated dataset of dental conditions. This dataset will encompass at least 28 distinct dental conditions, along with their associated symptoms, severity levels, and confirmed diagnoses, all validated by certified dental professionals. The training process will employ supervised machine learning techniques to ensure high accuracy in pattern recognition and predictive capabilities. The system must seamlessly integrate this AI model, ensuring low-latency communication between the frontend and backend for real-time diagnosis generation. Regular updates to the AI model, incorporating new research and clinical data, must be feasible without significant system downtime.
- **Clear and Probabilistic Diagnosis Presentation:** The AI-generated diagnosis results must be presented to the patient in an exceptionally clear, concise, and easily understandable format. This includes listing the most probable dental conditions,

along with a confidence score or probability percentage for each, indicating the AI's certainty. For example, "Potential Condition: Gingivitis (75% confidence)" or "High Likelihood: Cavity (90% confidence)." The output will avoid overly technical jargon, using plain language that empowers the user with initial insights without causing undue alarm.

- **Actionable Recommendations and Disclaimers:** Alongside the preliminary diagnosis, the system must consistently provide clear, actionable recommendations. These recommendations will vary based on the severity and urgency indicated by the AI's assessment. Examples include: "It is highly recommended to consult a dentist within 24-48 hours" for potentially urgent conditions, or "Consider scheduling a routine check-up with your dentist" for less severe concerns. Crucially, every diagnosis presented must be accompanied by a prominent and unambiguous disclaimer stating that Klepio's assessment is preliminary, does not constitute a definitive medical diagnosis, and is not a substitute for professional dental advice, examination, or treatment. This disclaimer will be visually distinct and require explicit user acknowledgement.
- **Continuous Learning and Refinement:** The AI model should be designed with continuous learning capabilities. This involves mechanisms for dental professionals to provide feedback on the AI's predictions (e.g., confirming or correcting a diagnosis in the Doctor's Access portal), which can then be used to retrain and refine the model periodically. This iterative improvement process ensures that Klepio's diagnostic accuracy evolves and improves over time, reflecting the latest clinical understanding and patient outcomes.

3.1.3 Doctor's Access to Patient Information

This critical feature provides a secure and specialized portal for dental professionals to review, verify, and utilize patient-generated data and AI insights, enhancing their diagnostic workflow.

- **Secure and Comprehensive Patient Data Review Portal:** The system must provide a secure, authenticated web portal exclusively for registered dental professionals. Through this portal, doctors will have access to a comprehensive summary of their patients' self-assessment responses. This includes not only the AI's preliminary findings but also the complete, unedited raw data from the questionnaire, allowing for a thorough understanding of the patient's reported symptoms, medical history, and specific details provided. The portal will include robust search and filtering capabilities (e.g., by patient name, date of assessment, or AI-predicted condition) to facilitate efficient patient management.
- **AI Prediction Verification and Refinement:** The doctor's portal will prominently display the AI-generated preliminary diagnoses, including the confidence scores and any associated recommendations. This allows doctors to quickly grasp the AI's initial assessment. Crucially, the system must provide functionalities for doctors to verify, override, or refine the AI's predictions based on their clinical judgment, physical examination findings, and additional diagnostic tests. This could involve selecting a confirmed diagnosis from a predefined list, adding specific notes about the discrepancy, or marking the AI's prediction as confirmed.

- **Integrated Note-Taking and Consultation Summary:** The system will provide integrated functionalities for doctors to add their own clinical notes, observations, and confirmed diagnoses directly within the patient's record on the Klepio platform. This feature will support rich text formatting and allow for the attachment of relevant files (e.g., X-ray images, treatment plans, though direct image uploads to Klepio should be handled carefully due to storage and privacy considerations, perhaps linking to external secure storage). This comprehensive record of the consultation, combined with the initial self-assessment, creates a holistic patient overview within Klepio, which can be easily retrieved for follow-up appointments or shared securely with other healthcare providers (with patient consent). An audit trail of all doctor actions and modifications to patient records will be maintained for accountability and compliance.

3.1.4 User-Friendly Interface

This overarching functional requirement ensures that the entire Klepio application is intuitive, accessible, and provides a positive and seamless user experience for all user classes, regardless of their technical proficiency or device.

- **Highly Responsive and Adaptive Design:** The user interface must be designed with a "mobile-first" approach and be fully responsive, adapting seamlessly to various screen sizes, resolutions, and orientations (portrait/landscape) across a wide range of devices, including desktops, laptops, tablets, and smartphones. This ensures consistent usability and optimal readability without compromising functionality or aesthetics. Layouts, font sizes, image scaling, and interactive elements will dynamically adjust to provide an optimal viewing and interaction experience on any device.
- **Intuitive Navigation and Clear Controls:** Navigation within the application must be intuitive, logical, and easy to understand, even for first-time users. This includes clear, descriptive labels for menus, buttons, and interactive elements. A consistent navigation structure (e.g., persistent headers/footers, breadcrumbs) will help users understand their current location within the application and easily move between sections. All interactive controls (buttons, checkboxes, sliders) will be clearly distinguishable, appropriately sized for touch interaction, and provide immediate visual feedback upon interaction.
- **Real-time Feedback and Error Handling:** Users should receive immediate and clear real-time feedback on their interactions and the system's status. This includes visual cues for button clicks, loading indicators for background processes (e.g., "Analyzing symptoms..."), success messages for completed actions (e.g., "Assessment submitted successfully!"), and clear, actionable error messages for any issues encountered (e.g., "Please check your internet connection"). The system will avoid abrupt failures, instead providing graceful degradation or informative messages when unexpected issues occur.
- **Comprehensive Accessibility Features:** Adherence to widely recognized web accessibility standards, such as the Web Content Accessibility Guidelines (WCAG 2.1 AA), will be a priority. This includes ensuring full keyboard navigability for users who cannot use a mouse, sufficient color contrast for text and interactive elements to assist users with visual impairments, compatibility with screen readers, and clear

semantic HTML structure. Providing alternative text for images and captions for any multimedia content will also be implemented to ensure inclusivity for all users.

3.1.5 Comprehensive Questionnaire

The quality and comprehensiveness of the questionnaire are paramount to the accuracy of the AI's diagnosis.

- **Expert-Validated Content and Structure:** The questionnaire content, including the wording of questions, the range of possible answers, and the logical flow, must be meticulously researched and thoroughly validated by a panel of experienced dental professionals. This ensures that the questions effectively capture all necessary information for accurate diagnosis across the targeted 28 dental conditions. Questions will be structured to cover a wide range of symptom categories (e.g., pain, swelling, sensitivity, bleeding), their characteristics, duration, and associated factors, as well as relevant medical history and lifestyle habits.
- **Iterative Refinement and Continuous Improvement:** The questionnaire is not a static component; it must be designed for iterative refinement. Mechanisms will be in place to collect user feedback on the clarity and effectiveness of questions. Furthermore, the performance of the AI model will directly inform potential adjustments to the questionnaire. For example, if the AI consistently struggles with certain diagnostic distinctions, the questionnaire might be refined to elicit more specific information in those areas. This continuous improvement loop ensures the questionnaire remains highly effective and relevant.

3.1.6 PDF Report Generation

- **On-Demand Comprehensive Report Creation:** Users will have the option to generate and download a comprehensive PDF report of their self-assessment and the AI's preliminary diagnosis. This report will include a summary of all symptoms reported by the user, the AI's predicted conditions with their confidence scores, and a clear reiteration of the disclaimer that the assessment is preliminary and not a substitute for professional medical advice. It may also include general recommendations for seeking professional dental care.
- **Professional Formatting and Secure Sharing:** The PDF reports will be professionally formatted, ensuring clarity, readability, and a consistent brand identity. The layout will be clean, well-organised, and suitable for printing or digital sharing. The system will also consider implementing secure sharing options, allowing users to securely transmit their reports directly to their dental professional through an integrated, encrypted channel, with explicit user consent. This streamlines information exchange between patients and their healthcare providers.

3.2 Non-Functional Requirements

Non-functional requirements specify the quality attributes of the system, defining how well the system performs its functions.

3.2.1 Performance

Performance requirements dictate the speed, responsiveness, and efficiency of the Klepio application under various conditions.

- **AI-Based Diagnosis Response Time:** The system must process user inputs and return AI-based diagnoses within a maximum of **30 seconds** from the moment the user submits their questionnaire. This latency includes data transmission, AI model inference, and result presentation. Optimization strategies will focus on efficient data serialization, optimized AI model execution (e.g., using optimized libraries, potentially GPU acceleration for complex models), and streamlined backend processing to meet this critical user expectation.
- **User Interface Responsiveness:** The UI must be highly responsive, with all interactive elements (buttons, forms, navigation) responding to user actions within **1 second**. Page load times for initial access and subsequent navigation between major sections should not exceed **3 seconds** on a standard broadband connection (e.g., 25 Mbps). This ensures a fluid and engaging user experience, preventing frustration due to delays.
- **Scalability for Concurrent Users:** The system should be designed to support a minimum of **100 concurrent users** actively conducting self-assessments or reviewing diagnoses without significant degradation in performance (i.e., maintaining the specified response times). The architecture will leverage cloud-native services and auto-scaling capabilities to dynamically adjust resources based on user load, ensuring consistent performance during peak usage periods.
- **Data Transfer Rates:** The application should aim for optimized data transfer rates. While user input data for the questionnaire is relatively small, future features like PDF report generation or potential image uploads (if introduced) will require efficient handling. The system will employ data compression techniques and optimized network protocols (HTTPS) to ensure efficient data exchange.

3.2.2 Security & Privacy

Security and privacy requirements are paramount for Klepio, given its handling of sensitive personal health information.

- **Secure Data Storage and Encryption:** All user data, including questionnaire responses, preliminary diagnoses, and any associated doctor's notes, must be stored securely. This includes encryption of data at rest (e.g., database encryption) and in transit (using TLS/SSL for all communication). The database containing patient information must be protected by robust access controls, firewalls, and intrusion detection systems. Regular data backups will be performed and encrypted.
- **Compliance with Data Protection Laws:** Klepio must be fully compliant with all applicable data protection and privacy laws, including but not limited to the General Data Protection Regulation (GDPR) for users within the European Union and the Health Insurance Portability and Accountability Act (HIPAA) for users within the United States. This involves implementing strict data minimization principles, ensuring data anonymization or pseudonymization where appropriate, providing clear

consent mechanisms, and facilitating user rights (e.g., right to access, rectification, erasure).

- **Robust User Authentication and Authorization:** Access to Klepio's features, particularly the doctor's portal and any personalized patient data, must be protected by strong authentication mechanisms. This includes secure username/password combinations, multi-factor authentication (MFA) where feasible, and session management best practices (e.g., secure cookies, session timeouts). Role-based access control (RBAC) will be implemented to ensure that users (patients, doctors, administrators) only have access to functionalities and data appropriate for their assigned roles.
- **Regular Security Audits and Vulnerability Assessments:** The application and its underlying infrastructure will undergo regular security audits, penetration testing, and vulnerability assessments by independent third parties. Any identified vulnerabilities must be addressed promptly, with a defined patch management process. Continuous monitoring for suspicious activities and security incidents will be in place, with clear incident response plans.

3.2.3 Availability & Reliability

These requirements ensure that Klepio is consistently accessible and performs its functions without failure.

- **High System Uptime:** The system should maintain a high uptime of at least **99.9%** (excluding planned maintenance windows), ensuring users can access the application anytime they need it. This translates to a maximum of approximately 8.76 hours of downtime per year. To achieve this, the system will employ redundant servers, load balancing, and failover mechanisms across multiple availability zones in the chosen cloud provider.
- **Effective Error-Handling and Recovery:** Proper error-handling mechanisms must be in place across all layers of the application (frontend, backend, database, AI model). This includes comprehensive logging of errors, graceful degradation (e.g., providing a user-friendly message instead of crashing), and automated recovery procedures for common failures. The system should be able to recover from unexpected outages with minimal data loss and service interruption.
- **Data Backup and Disaster Recovery:** Comprehensive data backup strategies will be implemented, including regular automated backups of all critical data (e.g., daily full backups, hourly incremental backups) to geographically separate locations. A well-defined disaster recovery plan will be in place, outlining procedures for restoring the system to full operation within a specified Recovery Time Objective (RTO) and minimizing data loss within a defined Recovery Point Objective (RPO) in the event of a major disaster.

3.2.4 Maintainability & Scalability

These requirements ensure that Klepio can be easily updated, modified, and expanded to meet future demands and evolving requirements.

- **Ease of Updates and Modifications:** The system's architecture will be modular and well-documented, facilitating easy updates, bug fixes, and the integration of new features without causing significant disruptions to existing functionalities. Adherence to established coding standards, clear API contracts between modules, and comprehensive inline documentation will be enforced. A robust Continuous Integration/Continuous Deployment (CI/CD) pipeline will automate testing and deployment processes, enabling rapid and reliable updates.
- **Scalability of Infrastructure and AI Model:** The system must be inherently scalable to accommodate a growing user base and increasing data volume. This includes:
    - **Horizontal Scalability:** The ability to add more servers or instances (e.g., web servers, application servers, database replicas) to handle increased load without requiring changes to the application code. This will be achieved through cloud-native services that support auto-scaling.
    - **Database Scalability:** The chosen database (SQLite for initial phase, with consideration for a more scalable solution like PostgreSQL or a NoSQL database for future growth) must support efficient scaling strategies, including read replicas, sharding, or clustering, to handle growing data volumes and query loads.
    - **AI Model Scalability:** The AI inference engine must be capable of scaling to handle a large number of simultaneous diagnosis requests, potentially leveraging containerization (e.g., Docker) and orchestration (e.g., Kubernetes) for efficient resource management and deployment.
- **Code Quality and Testability:** The codebase will adhere to high standards of code quality, readability, and maintainability. This includes comprehensive unit, integration, and end-to-end testing frameworks to ensure that new features or modifications do not introduce regressions. Code reviews will be a mandatory part of the development process to ensure adherence to best practices and maintain architectural integrity.
- **Technical Debt Management:** A proactive approach to managing technical debt will be implemented, including regular refactoring efforts and dedicated time for addressing architectural improvements, ensuring the long-term health and evolvability of the codebase.

4. External Interface Requirements

This section details the external interfaces with which the Klepio system must interact. These interfaces define how the system communicates with users, hardware, other software systems, and external communication protocols. Ensuring robust and well-defined interfaces is critical for the system's usability, integration capabilities, and overall functionality.

4.1 User Interfaces

The user interfaces are the primary means by which patients and dental professionals interact with the Klepio application. These interfaces must be intuitive, responsive, and accessible to ensure a seamless and effective user experience.

- **Simple, Web-Based UI Optimized for Desktop and Mobile:** The primary user interface for Klepio will be a web-based application, accessible through standard web

browsers. It must be meticulously designed and optimized for both desktop and mobile users, ensuring full responsiveness across a wide range of screen sizes and orientations. This optimization includes fluid layouts, appropriately sized touch targets for mobile devices, and efficient loading of content to accommodate varying network conditions. The design will prioritize clarity, minimalism, and ease of navigation to reduce cognitive load and enhance user satisfaction.

- **Clear Input Fields and Interactive Questionnaire Layout:** The user interface for the patient self-assessment must feature clear, well-labeled input fields that are easy to understand and interact with. The questionnaire layout will be highly interactive and dynamic, adapting the flow of questions based on previous user responses to ensure relevance and efficiency. Visual cues, such as progress bars or indicators, will guide users through the assessment process. For example, radio buttons and checkboxes will be used for discrete choices, while text areas will allow for more detailed textual input. Input validation will provide immediate feedback to users, guiding them to correct or complete information effectively.
- **Doctor's Portal Interface:** A distinct, secure web-based interface will be provided for dental professionals. This portal will feature a dashboard view that summarizes patient assessments, AI-generated predictions, and allows for efficient patient record management. It will include functionalities for searching, filtering, and sorting patient data. The interface will support clear display of detailed patient responses, AI confidence scores, and provide intuitive controls for adding clinical notes, verifying diagnoses, and potentially communicating with patients (if future communication features are implemented). The design will prioritize data readability and efficient workflow for busy medical practitioners.
- **Accessibility Features Integration:** The user interfaces must adhere to established web accessibility standards (e.g., WCAG 2.1 AA). This includes providing sufficient color contrast, ensuring keyboard navigability for all interactive elements, supporting screen readers, and providing clear semantic HTML structures. Alternative text for images and captions for any multimedia content will be implemented to ensure that the application is usable by individuals with diverse abilities.

4.2 Hardware Interfaces

Klepio, being a web-based application, primarily interacts with hardware through the user's computing device and network infrastructure.

- **Compatibility with Standard Devices:** The system must be compatible with standard computing devices commonly used by patients and dental professionals. This includes personal computers (desktops and laptops), tablets, and smartphones. The application's responsiveness (as detailed in Section 3.2.4) will ensure optimal display and interaction across these device types, regardless of screen size or input method (mouse, keyboard, touch).
- **Internet Access Requirement:** A stable and active internet connection is a fundamental hardware interface requirement. Klepio relies on internet connectivity to transmit user input to the backend, receive AI-generated diagnoses, and access cloud-based services. While the application will be designed to handle intermittent connectivity gracefully (e.g., by providing clear error messages), continuous access to the internet is necessary for full functionality.

- **Standard Input/Output Devices:** The application will utilize standard input devices such as keyboards, mice, and touchscreens for user interaction. Output will be displayed on standard display monitors or screens. No specialized hardware interfaces (e.g., medical imaging devices, proprietary sensors) are required for the core functionality of Klepio.

4.3 Software Interfaces

Klepio interacts with various software components and systems to deliver its functionality. These interfaces define the necessary software environments and communication protocols.

- **Frontend Technologies (React.js, HTML, CSS, JS):** The client-side of Klepio, which constitutes the User Interface, will be developed using modern web technologies. Specifically, **React.js** will serve as the primary JavaScript library for building dynamic and interactive user interfaces. **HTML5** will provide the structural foundation, **CSS3** will be used for styling and responsive design, and **JavaScript (ES6+)** will handle client-side logic and interactivity. The system will assume that the user's web browser (e.g., Google Chrome, Mozilla Firefox, Microsoft Edge, Safari) is up-to-date and supports these modern web standards.
- **Backend Technologies (Python-based AI Model, REST API, Django):** The server-side of Klepio will be robustly built to handle data processing, AI model inference, and database interactions.
    - **Python-based AI Model:** The core diagnostic intelligence will reside within a Python-based Artificial Intelligence model. This model will be responsible for analyzing patient symptoms and generating preliminary diagnoses. The system will interface with this model programmatically.
    - **REST API:** Communication between the frontend and the backend, including interactions with the AI model, will be facilitated through a **RESTful API**. This API will define a standardised set of endpoints, request methods (GET, POST), and data formats (JSON) for all data exchange. This ensures interoperability and allows for future integration with other systems.
    - **Django Framework:** The backend application logic, including user authentication, data management, and API endpoint handling, will be implemented using the **Django** web framework (Python). Django's robust features for security, database interaction, and rapid development make it an ideal choice for the Klepio backend.
- **Database (SQLite for initial phase, scalable solution for production):** For the initial development and potentially smaller deployments, **SQLite** will be used as the database. SQLite is a lightweight, file-based database that is easy to set up and manage. However, for production deployments and to ensure scalability for a growing user base and data volume, the system will transition to a more robust and scalable relational database management system (RDBMS) such as **PostgreSQL** or a NoSQL solution, depending on the specific scalability requirements and data structure evolution. The database will store user profiles, questionnaire responses, AI predictions, and doctor's notes.
- **Operating System Compatibility:** While Klepio is a web application, its backend components will operate on a server-side operating system, typically Linux distributions (e.g., Ubuntu, CentOS) for stability, security, and performance. On the

client side, the application will be accessible from devices running major operating systems such as Windows, macOS, Android, and iOS, relying on their respective web browsers.

4.4 Communication Interfaces

Effective and secure communication is fundamental to Klepio's operation, ensuring reliable data exchange between all system components and external entities.

- **HTTPS for Secure Web Transactions:** All web-based communication between the user's browser (frontend) and the Klepio server (backend) must exclusively use **HTTPS (Hypertext Transfer Protocol Secure)**. This ensures that all data transmitted, including sensitive patient information and diagnostic results, is encrypted using TLS/SSL protocols. HTTPS protects against eavesdropping, tampering, and message forgery, thereby maintaining data confidentiality and integrity.
- **API Integration for AI Model Queries:** Communication between the Django backend and the Python-based AI model will primarily occur through internal API calls. These calls will be optimized for speed and efficiency, ensuring that AI predictions are returned within the specified performance thresholds (as per Section 3.2.1). The API will be designed to handle data serialization and deserialization (e.g., JSON payloads) for seamless exchange of symptoms and diagnostic results.
- **Secure Data Exchange Protocols:** Beyond HTTPS, any internal service-to-service communication within the Klepio architecture (e.g., between the Django application and a separate microservice for PDF generation, if implemented) will utilize secure, authenticated protocols. This might involve internal network encryption, API keys, or token-based authentication to prevent unauthorized access to internal services.
- **Error Reporting and Logging:** The system will implement robust communication interfaces for error reporting and logging. This includes mechanisms for the frontend to report client-side errors to the backend, and for the backend to log operational errors, security events, and performance metrics to a centralized logging system. This ensures that system administrators can monitor the application's health, diagnose issues, and respond proactively to potential problems.
- **Potential Third-Party Integrations (Future):** While not in the initial scope, future enhancements may involve communication interfaces with third-party services. This could include integration with email notification services (e.g., SMTP for sending appointment reminders or report availability notifications), or potentially secure health information exchange networks (with strict adherence to privacy regulations). Any such integrations will require well-defined APIs and robust security protocols.

5. System Features

This section provides a high-level overview of the main system features of Klepio, outlining the primary functionalities that the application will offer to its users. These features encapsulate the core value proposition of Klepio as an AI-driven dental diagnostic assistant.

5.1 Self-Assessment System

The Self-Assessment System is the cornerstone of the Klepio application, designed to empower patients to conduct an initial evaluation of their dental health. This system is built around an intelligent, user-friendly questionnaire that guides individuals through a series of symptom-related inquiries.

- **Dynamic and Intelligent Questionnaire:** The system will provide a dynamic questionnaire that adapts its flow and content based on the user's previous responses. This intelligent design ensures that only relevant questions are presented, making the assessment process efficient and tailored to the individual's reported symptoms. For example, if a user indicates pain in a specific tooth, the system will follow up with more detailed questions about the nature, intensity, and triggers of that pain. This adaptive questioning minimizes user fatigue and maximizes the quality of data collected for the AI.
- **Comprehensive Symptom Capture:** The questionnaire is meticulously designed to cover a wide spectrum of dental symptoms, including but not limited to pain (sharp, dull, throbbing), sensitivity (to hot, cold, sweet), swelling, bleeding gums, bad breath, jaw pain, clicking sounds, and changes in tooth appearance. It will also inquire about relevant medical history, medications, and lifestyle factors that could influence oral health. The goal is to capture all necessary information for the AI model to make an informed preliminary diagnosis.
- **User-Friendly Interface for Input:** The interface for the self-assessment will be highly intuitive, featuring clear input fields, easy-to-understand language, and visual aids where appropriate. It will support various input types such as multiple-choice questions, radio buttons, checkboxes, and free-text fields for detailed descriptions. The design will prioritize simplicity and accessibility, ensuring that users with varying levels of technical proficiency can navigate and complete the assessment without difficulty.
- **Real-time Progress Tracking:** To enhance the user experience and manage expectations, the system will display clear indicators of progress through the questionnaire, such as a percentage completion bar or "Question X of Y." This helps users understand how much more information is required and encourages them to complete the assessment.
- **AI-Driven Preliminary Diagnosis Generation:** Upon completion of the questionnaire, the system will leverage its integrated AI model to process the collected symptom data. The AI will analyze the patterns within the reported symptoms and compare them against its extensive dataset of dental conditions to generate a preliminary diagnosis. This diagnosis will include a list of potential dental conditions, along with a confidence score for each, indicating the AI's likelihood of accuracy. The results will be presented in a clear, non-technical manner, always accompanied by a prominent disclaimer that it is a preliminary assessment and not a substitute for professional medical advice.
- **Guided Information Gathering:** The system's design encourages users to provide comprehensive information by making the process straightforward and engaging. The adaptive nature of the questionnaire means that users are prompted for specific details relevant to their initial responses, ensuring that the AI receives the most

pertinent data for analysis. This contrasts with open-ended symptom descriptions that might miss crucial details.

- **Immediate (Preliminary) Feedback:** One of the key benefits of the Self-Assessment System is the immediate feedback in the form of a preliminary diagnosis. This instant insight can help users decide on their next steps, whether it's scheduling an urgent appointment or simply monitoring a minor symptom. The confidence scores provided by the AI give users a sense of the assessment's certainty, guiding their decision-making.
- **Foundation for Doctor Review:** The data collected through the Self-Assessment System forms the essential foundation for the Doctor Review System. By having pre-analyzed, structured symptom information and AI predictions, dental professionals can significantly reduce the time spent on initial patient interviews, allowing them to focus more on physical examination and personalized treatment planning during the actual consultation. This pre-consultation data improves the efficiency and effectiveness of dental appointments.
- **Data Security and Privacy:** Throughout the self-assessment process, the system will adhere to stringent data security and privacy protocols. All user inputs and generated preliminary diagnoses will be encrypted during transmission and at rest, complying with regulations such as GDPR and HIPAA. Users will be informed about how their data is used and have control over their personal health information.
- **Scalability and Performance:** The Self-Assessment System is designed to be highly scalable, capable of handling a large volume of concurrent users without degradation in performance. The backend infrastructure and AI model integration are optimized to process questionnaire submissions and generate diagnoses within the specified timeframes (e.g., 30 seconds for AI diagnosis), ensuring a smooth and responsive experience even during peak usage.

5.2 Doctor Review System

The Doctor Review System provides a secure and specialised interface for dental professionals to access, review, and manage patient self-assessment data and AI-generated predictions. This system is designed to streamline the diagnostic workflow for dentists and enhance their ability to provide informed care.

- **Comprehensive Patient Dashboard:** Doctors will access a personalised dashboard that provides an organised overview of their patients. This dashboard will allow them to see a list of patients who have completed self-assessments, view their status (e.g., "New Assessment," "Reviewed"), and prioritise cases. Quick filters and search functionalities will enable efficient navigation through patient records.
- **Detailed Patient Response Display:** The system will display all patient responses from the self-assessment questionnaire in a clear, structured, and easily digestible format. This includes every question asked and the corresponding answer provided by the patient. This detailed view allows doctors to gain a complete understanding of the patient's reported symptoms and history, providing context for the AI's predictions.
- **AI Prediction Visualisation and Verification:** The Doctor Review System will prominently display the AI-generated preliminary diagnoses for each patient, including the confidence scores associated with each predicted condition. Doctors

will have the ability to visually review these predictions and, crucially, to verify, modify, or override them based on their clinical expertise, physical examination findings, and any additional diagnostic tests. This feature supports a collaborative diagnostic process where AI assists, but human judgment remains paramount.

- **Workflow Optimisation:** By presenting patient symptoms and AI predictions in a pre-digested format, the system significantly optimizes the doctor's workflow. Instead of spending valuable consultation time gathering basic symptom information, doctors can quickly review the Klepio assessment and immediately delve into targeted questions or examinations. This efficiency can lead to shorter appointment times or allow for more in-depth discussions with patients.
- **Enhanced Diagnostic Support:** The AI predictions serve as a valuable second opinion or a starting point for diagnosis. While doctors retain full autonomy and responsibility for the final diagnosis, the AI's insights can help them consider conditions they might not have initially thought of, especially in complex or ambiguous cases. The confidence scores provide a quantitative measure of the AI's certainty, further aiding the doctor's decision-making process.

5.3 Future Enhancements

Klepio is designed with a roadmap for continuous improvement and expansion. The following are key enhancements planned for future releases, aimed at broadening the application's utility and user base.

- **Expansion of the AI Model:** The AI model's diagnostic capabilities will be continuously expanded to include a broader range of dental conditions. Initially targeting 28 conditions, future updates will incorporate more complex and nuanced diagnoses, potentially extending into specialized fields of dentistry (e.g., orthodontics, periodontics, endodontics). This expansion will involve further training of the AI model on new, validated datasets and continuous collaboration with dental experts to ensure accuracy and relevance.
- **Integration with Tele-dentistry Platforms:** A significant future enhancement could involve integrating Klepio with existing tele-dentistry platforms. This would allow for a more seamless transition from a self-assessment to a virtual consultation with a dental professional, potentially including video calls and secure messaging within the Klepio ecosystem or through direct links to partner platforms.
- **Personalised Oral Hygiene Recommendations:** Based on the AI's diagnosis and general patient information, future versions could provide personalized oral hygiene recommendations. For example, if the AI predicts gingivitis, the system might suggest specific brushing techniques, flossing routines, or mouthwash recommendations. These recommendations would be general in nature and emphasise the importance of professional guidance.
- **Symptom Tracking and Historical Data:** Users could be given the ability to track their symptoms over time and view a history of their past self-assessments. This

feature would allow them to monitor the progression or resolution of symptoms and share this longitudinal data with their dentists, providing a more complete picture of their dental health journey.

- **Integration with Wearable Devices (Exploratory):** As technology advances, an exploratory future enhancement could involve integrating with certain wearable devices or smart oral hygiene tools (e.g., smart toothbrushes) to gather passive data that could further inform the AI's diagnostic capabilities, with strict user consent and data privacy considerations.
- **Integrated Note-Taking and Consultation Documentation:** The system will provide robust functionality for doctors to add their own clinical notes, observations, and confirmed diagnoses directly within the patient's digital record on the Klepio platform. This includes free-text fields for detailed notes, and potentially structured input for common findings. This feature facilitates comprehensive documentation of the consultation, creating a holistic patient history that combines self-reported symptoms, AI insights, and professional findings. These notes will be securely stored and accessible for future reference.