1.1 User Needs:

Global Context:

* Oral diseases affect ~3.7 billion people worldwide [1]
* Common issues: cavities, gum inflammation, calculus buildup, missing teeth, misalignment, and discoloration.
* Many adults delay dental visits causing problems worsen
* Barriers: cost, limited access, lack of awareness, fear of dentists [2]
* Preventive care can reduce disease burden and treatment cost [3] [4] [5]

Stakeholder Feedback:

* App should help with self-monitoring of oral health via photos.
* Target detection/monitoring: cavities, gum issues, missing teeth, misalignment, whitening/discoloration.
* Accuracy limits acknowledged no X-ray, so focus on screening, tracking, education.
* Possible feature: connect with dentist remotely.
* In China, similar apps used by dentists to monitor patient progress, our design shifts toward user-empowerment model.

Scientific Support for Early Prevention / Detection:

* Less invasive treatments: which can result in shorter recovery times, reduced discomfort, and lower costs. For instance, treating a small cavity is generally less complicated than addressing extensive tooth decay that requires a root canal or extraction.
* Improved treatment outcomes increases the likelihood of successful treatment outcomes. For example, gum disease in its early stages can often be managed through non-surgical methods, while more advanced stages may require surgical intervention.
* Prevention of complications: Timely treatment of dental issues can help prevent complications, such as the spread of infection or damage to neighboring teeth and supporting structures [6].
* Early dental visits correlate with better treatment experience for dental caries [7]
* Early identification of enamel lesions enables non-invasive intervention of dental caries. [8]
* Transition to colored images working together with x-ray
* Imaging tools show strong potential for early oral disease detection:
  + OralCam enables end-users to self-examinate five common oral conditions by taking smartphone photos [9]
  + Using deep convolutional neural network (CNN) model to classify teeth with periodontal diseases from optical color images [10]
  + Screen gingivitis and its irritants, i.e., dental calculus and soft deposits, from oral photos with a novel Multi-Task Learning convolutional neural network (CNN) model [11].
  + MobileNetV3-Small trained to detect cavities on RGB images [12]
  + Automatic diagnosis model trained by MASK R-CNN developed for the detection and classication of 7 different dental diseases for in clinic use [13]
  + Multi-task learning (MTL) convolutional neural network for tooth localization, caries detection, and fissure sealant detection (dataset available upon request) [14]
  + **Artificial intelligence for dental caries detection: A mixup, fine-tuning, and quantization approach on the MobileNetV2 model [15]**
    - Need artificial intelligence (AI)-driven diagnostic tools that are accurate, portable, cost-effective, and accessible to wider populations.
    - A significant challenge arises when models trained on clinical datasets are deployed in nonclinical environments. Smartphone images typically exhibit variations in lighting, resolution, and angles, leading to performance degradation due to domain shift.
    - Lightweight CNN models such as MobileNetV2 have been developed for efficient inference on edge devices, including smartphones with fewer parameters and lower computational demands.
  + Artificial Intelligence in Dental Caries Diagnosis and Detection: An Umbrella Review [16]
  + Accuracy of Artificial Intelligence-Based Photographic Detection of Gingivitis [17]
* Combination of images and asking for information (i.e. if there is bleeding? If there is pain while chewing? Sensitivities?)

**Preliminary Need Statement:**

**There is a need for an accessible, user-friendly application to help users identify early signs of oral health issues and support self-monitoring， particularly for populations with limited access to regular dental care.**

Impacts:

* Health Impact:
  + Promotes early detection leading to fewer severe oral conditions.
  + Encourages preventive care and self-awareness.
  + Supports WHO’s oral health strategy focused on prevention.
* Social & Economic Impact:
  + Reduces treatment costs by catching issues earlier.
  + Bridges inequality gap, benefits underserved, low-income, or rural populations.
    - Low-income adults have higher rates of untreated caries and missing teeth [18]
    - Children aged 6 to 9 from lower income households were more than twice as likely (25%) to have untreated cavities than children from higher income households [18]
    - Disparities in oral health care access among low-income, uninsured, rural, minority, and immigrant populations [19]
    - Aging adults face inequities due to socioeconomic and literacy barriers [20]
  + Encourages equitable access to oral healthcare.
* Technological & Environmental Impact:
  + Uses smartphones low-cost & sustainability
  + Easily scalable and adaptable across languages/cultures.
* Cultural & Ethical Impact:
  + Emphasizes education, privacy, and guidance, not self-diagnosis.
    - Monitoring oral health remotely: ethical considerations when using AI among vulnerable populations [21]
    - The Use of Patient-Oriented Mobile Phone Apps in Oral Health: Scoping Review [22]
      * Many studies that have used mobile apps have focused on promoting oral health. However, other areas such as diagnostic and remote consultations (teledentistry) [23].
  + Respects cultural differences in health engagement.
  + Complements dentists rather than replacing them.

Traditional Image Analysis:

* Color and Intensity Analysis
  + Detect discoloration, plaque buildup, gum redness (possible inflammation).
    - RGB thresholding (e.g., red = inflamed gum area)
    - Colorimetric analysis of intraoral scans: A novel approach for detecting gingival inflammation [23]
* Edge Detection
  + Identifies boundaries between regions (teeth, gums, cavities).
  + Outline tooth contours, detect misalignment, identify gaps or missing teeth.
* Shape and Contour Analysis
  + Detect crooked teeth, missing teeth, or gum line irregularities.
    - Contour tracing and convex hull detection
    - Hough Transform
* Texture Analysis
  + Differentiate smooth enamel vs. rough surfaces (plaque, tartar)
* Thresholding and Segmentation
  + Separates objects (teeth, gums) from background. Isolate and focus on teeth only.
    - Enhancing Dental Image Segmentation Techniques: Edge Detection and Color Thresholding [24]
* Optical Flow or Feature Matching (Progress Monitoring)
  + Monitoring progression of discoloration, gum recession, or whitening.
  + Adapt for orthodontics?

References:

[1] https://www.who.int/news-room/fact-sheets/detail/oral-health

[2] https://pubmed.ncbi.nlm.nih.gov/31327369/

[3] https://www.thelancet.com/journals/lancet/article/PIIS0140-6736(24)02811-3/fulltext

[4] https://onlinelibrary.wiley.com/doi/10.1111/jcpe.12677

[5] https://onlinelibrary.wiley.com/doi/abs/10.1111/j.1600-0528.1997.tb00894.x?sid=nlm%3Apubmed

[6] https://exceldental.ca/general-dentistry/early-detection-and-treatment-of-dental-issues-the-key-to-optimal-oral-health-and-well-being/

[7] https://pmc.ncbi.nlm.nih.gov/articles/PMC4167088/

[8] https://pubmed.ncbi.nlm.nih.gov/38132233/

[9] https://dl.acm.org/doi/pdf/10.1145/3313831.3376238

[10] https://www.mdpi.com/2079-9292/12/7/1518

[11] https://www.nature.com/articles/s41598-021-96091-3

[12] https://arxiv.org/pdf/2308.15705

[13] https://www.researchgate.net/publication/333702517\_A\_Smart\_Dental\_Health-IoT\_Platform\_Based\_on\_Intelligent\_Hardware\_Deep\_Learning\_and\_Mobile\_Terminal

[14] https://bmcoralhealth.biomedcentral.com/articles/10.1186/s12903-024-04254-1

[15] https://pmc.ncbi.nlm.nih.gov/articles/PMC12377672/

[16] https://pmc.ncbi.nlm.nih.gov/articles/PMC11358700/

[17] https://pmc.ncbi.nlm.nih.gov/articles/PMC10509417/#sec0011

[18] https://www.cdc.gov/oral-health/data-research/facts-stats/index.html

[19] https://pmc.ncbi.nlm.nih.gov/articles/PMC7125002/

[20] https://www.frontiersin.org/journals/dental-medicine/articles/10.3389/fdmed.2025.1522892/full

[21] https://www.frontiersin.org/journals/oral-health/articles/10.3389/froh.2025.1587630/full

[22] https://pmc.ncbi.nlm.nih.gov/articles/PMC10512118/

[23] https://aap.onlinelibrary.wiley.com/doi/epdf/10.1002/JPER.24-0389

[24] https://www.semanticscholar.org/reader/51171008eb627ec83b1a1cdd4325682bd017db28

Potential Data Sets:

ODSI-DB – Oral and Dental Spectral Image Database

<https://sites.uef.fi/spectral/databases-software/odsi-db/>

Dental Calculus Dataset [10]

<https://github.com/PKNU-PR-ML-Lab/calculus>

Kaggle Dental Caries Dataset

<https://www.kaggle.com/datasets/maazmakhdoom/dental-cavity-detection-dataset>

Roboflow Cavity Detection Sets

<https://universe.roboflow.com/search?q=class%3Acavities>

1.4 Preliminary Risk Assessment  
**• Health and Safety**: Identify risks to end-users and the public’s health and safety that may arise from your project. Risks can be associated with the implementation,

prototyping, verification, manufacturing, or deployment associated with your project

Health/Safety-> more applications on radiographs in dental industry, not applicable to our application unless hardware design is included

Safety Specifically -> Data Encryption, personal privacy

**• Ethical Concerns**: Identify ethical concerns that may arise from your project and their impact on society

<https://scanoai.com/ethical-concerns-of-artificial-intelligence-in-dentistry/>

great website for identifying risks and potential solutions

**Exploring the Ethical Landscape of Artificial Intelligence in Dentistry: Insights from a Cross-Sectional Study**

<https://pmc.ncbi.nlm.nih.gov/articles/PMC12093131/#sec4>

* **Human Oversight & Liability**  
  • AI should support, not replace, dentists’ decisions  
  • Who is liable if AI leads to error? (consensus: AI shouldn’t carry full blame)
* **Transparency & Bias**  
  • AI “black box” problem — need explainability  
  • Bias in training data could skew outcomes
* **Informed Consent & Patient Autonomy**  
  • Patients must know AI’s role in care  
  • Must explain risks, uncertainties, alternatives
* **Data Privacy & Confidentiality**  
  • Sensitive dental/health data must be protected  
  • Storing in personal devices raises red flags
* **Financial Incentives / Conflicts of Interest**  
  • Referral fees from radiology centers may bias care decisions  
  • Overuse of imaging or treatments for profit
* **Disclosure of Complications & Errors**  
  • Must inform patients of problems (e.g. broken instruments)  
  • Withholding is unethical, even if outcome “acceptable”
* **Patient Demands vs Scientific Integrity**  
  • Reject requests for inappropriate procedures (e.g. crown on failing tooth)  
  • Respect patient wishes, but not at cost of professional ethics
* **Peer Accountability**  
  • Dilemma: when noticing substandard care in colleagues, should one report / inform patient?  
  • Many prefer to avoid conflict, but patient welfare may demand action
* **AI’s Limits in Moral Reasoning**  
  • AI may know rules and facts, but lacks empathy, context sensitivity  
  • Ethical decisions often require human nuance

**Legal issues in digital oral health: a scoping review**

<https://pmc.ncbi.nlm.nih.gov/articles/PMC10765871/#Sec10>

* **Privacy & Data Security**  
   • Handling massive amounts of patient data demands encryption, anonymization, secure storage.  
   • Risk: data breaches, misuse, unauthorized access.
* **Algorithmic Bias & Fairness**  
   • AI trained on skewed data may perpetuate health disparities.  
   • Need to monitor, correct, retrain models to ensure equitable outcomes.
* **Transparency, Explainability & Accountability**  
   • “Black box” decisions reduce trust — patients & clinicians need to understand AI reasoning.  
   • Clear responsibility: who is liable when AI errs (developer, institution, clinician)?
* **Human Oversight & Autonomy**  
   • AI should augment, not replace human judgment.  
   • Patients must be informed when AI is used, with risks/limits disclosed.
* **Impact on Health Professionals**  
   • Role shifts: clinicians may become supervisors of AI.  
   • Risk of deskilling or displacement if over-reliance on AI.
* **Societal Implications & Equity**  
   • Digital divide: some populations may lack access to AI-based care.  
   • Bias in deployment may widen inequities.
* **Regulation, Legal Challenges & Governance**  
   • Need adaptive, domain-specific rules (liability, data rights, IP).  
   • Ethical frameworks must evolve with technology.
* **Limits of Ethical Reasoning by AI**  
   • AI lacks empathy, moral intuition, nuanced contextual judgment.  
   • Some decisions require human values and deliberation.

<https://jada.ada.org/article/S0002-8177(24)00301-5/fulltext>

Article on what rules or policy AI should follow

WMA pólices:

<https://www.wma.net/policies-post/wma-statement-on-the-ethics-of-telemedicine/>

Archived telemedicine ethics: <https://www.wma.net/policies-post/wma-statement-on-guiding-principles-for-the-use-of-telehealth-for-the-provision-of-health-care/>

**• Standards and Codes**: Identify appropriate standards, codes, and legal or regulatory factors associated with your project's implementation, prototyping, verification, manufacturing, or deployment. What are the risks of non-compliance?

**Standards:**

* **CDHA** national professional organization that advocates for dental hygienist and promotes the profession
  + <https://files.cdha.ca/profession/ip/2022_Service_Codes_Appendix_EN.pdf>
* A white background with black text

  AI-generated content may be incorrect.
  + **CDHA Code of ethics**:
    - <https://cdha.org/Portals/CDHA/About/Governing%20Docs/CDHA%20Code%20of%20Ethics.pdf>
* **Standards** are set by provincial or territorial regulatory authority
* **Ontario: Follows CDA**
  + Ontario dental procedure codes are standardized, 5-digit alphanumeric codes based on the Canadian Dental Association (CDA) and other systems, used to identify services for billing and insurance purposes. General classification system groups code into categories
    - Diagnostic (00000-09999)
    - Preventive (10000-19999)
    - Restorative (20000-29999).
* **CDA Canadian Dental Association**
* a federally incorporated not-for-profit organization whose corporate members are Canada’s provincial and territorial dental associations (PTDAs).
* <https://hsps.pro/DentrixCanada/Help/mergedProjects/Office%20Manager/CDA_Dental_Codes_list.htm>
  + **Diagnostic codes**
    - <https://hsps.pro/DentrixCanada/Help/mergedProjects/Office%20Manager/CDA_Dental_Codes_list.htm#Diagnostic>   
      Note: It only provides a list of codes, short description + full name; we won’t understand without an expert’s help -> this might help for the common codes https://www.kwcdental.com/blog/dental-procedure-codes-ontario
  + **Ethical principles**
    - <https://www.cda-adc.ca/en/about/ethics/>
    - Note: These are the ethics that guide a dentist’s ethical practice, they are broad traits that lie under 2 categories specifically: Trust and Health

**Meeting with Dr. Smith 2025 10.16**

More accessible in China for dental health care; different in North America

Dr . Smith’s comment:

* There are people in America that would like to monitor all their health, so it has a potential market
* Glad that we looked in
* Thresholding is a segmentation technique -> google it a lot of AI comes up
* Using an existing model is acceptable, but training an AI is very difficult and unideal
  + - We have v2net v3 net that helps with this, use transfer learning
* More data sets – good very nice
* Q: Is gag required, is it a must for photo taking?  
  A: No, just to make pictures easier, if not used will require to take multiple pictures
* Need to talk to clients, potential clients and interview them ->ask their opinion
* Make an evidence-based decision to make capstone better
* Interface design (UI/UX) needs to ask users (friends, family members; could disclose the information)
* 10 individuals will be good 8-10 are good to show we are aware to the client’s need
* Surveys 5 mins (more data，put online)
* Real insight -> focus group/mock interface for individual (figma -> paper prototype) ask and show them how to use
  + People aren’t good enough to read design document so prototypes might be better
  + Min amount of typing
* Information tosses it in appendix
* Survey questions – Chapter 2 Could plan now the survey questions ahead and send them out asking about usability
* Google survey question and tweak it to meet our needs
  + Could let user themself to provide information themself on drop down
* Worst case if the diagnostic problems don't go well. It could be a method to collect information for the dentist
* Keeping everything broad ahead -> explore more design process   
  Start more general is a better approach
* Terms are a bit different between software stream and biomedical stream
* Deign inputs = constraints, requirements -> simplied software specification documents
* Want to say something about economic -> because we are targeting low-income people
* Is it washable
* Propose ideas you don't likes is okay i.e. surveys, mobile application, image analysis
* Dont mention the gag idea yet, its a design decision
* Give agenda ahead of time
* Use git hub to create issues and send it over to Dr. Smith and assign them to Dr. Smith

<https://github.com/ShadowOfShark/SFWRBME-5P06>

**Meeting with Dr. Vincent 2025 10.16**

**Agenda**

1. Apologize
2. Update Dr. Vincent
   1. Are there enough photos? Yes
3. Receive Feedback
4. Q: If we are not submitting DHF, where would the last 20% go for Chapter 1 draft
5. Any preference for how to hand back feedback

Go to teams for DHS set up -> send link in DHF need a document on how to access repo