DENTAL PATHOLOGY AND MACROWEAR

A biocultural analysis of southern African Holocene hunter-gatherers and hunter-herders

Judyta OLSZEWSKI

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Dla

Wujka Jurka i Bogdana oraz Mamy i Taty

„Jakoś to będzie”

«C’est le temps que tu as perdu pour ta rose qui fait ta rose si importante.»

Antoine de Saint-Exupéry, Le Petit Prince

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ABSTRACT

Dental macrowear quantity, direction, and oral pathology were assessed against demographic factors in southern African Holocene hunter-gatherers and -herders (sAHGH). This is the first study to investigate inter-related implications of diet, health, and behaviour across time and space using only teeth on a large sAHGH sample. This aim was accomplished through a systematic assessment of macroscopic dental examinations, particularly including direction, a method not yet addressed for sAHGH teeth. Data were obtained using a multimethod approach on 369 individuals and 6271 teeth and statistically analysed using R (version 4.1.3) and IBM© SPSS. The results showed a need for an adaptation of the Brabant index; therefore, I created a novel adaption to the method inclusive of a visual guide. Individuals were better preserved from coastal regions (n = 313) and young/middle-ages (n = 71), and sex and temporal divisions were similarly distributed, with fewer individuals dating to the earlier Holocene (n = 50). Wear quantity advanced rapidly, with increased odds in anterior teeth (OR=18, $p \leq 0.01$) and first molars (OR=4.6, $p \leq 0.01$). Horizontal and plane wear directions frequently occurred (n = 8321 teeth), and combined wear results reflected a plant-based diet and using teeth as tools. Tool use was further demonstrated by non-masticatory wear (n = 22) and microchipping (n = 55), elucidating behaviours such as occupational tasks and dental hygiene. Generally, the teeth demonstrated good health; however, the first molar was affected most frequently with antemortem tooth loss (OR=13.6, $p \leq 0.01$), infections (OR=4.4, $p \leq 0.01$), and caries (OR=28.7, $p \leq 0.01$). Overall, pathological lesions post-2000 BP reduced, suggesting health improvements. Notably, incidence rates for enamel hypoplasia on the first molars (n = 26) alluded to increased infant stress possibly related to herding. Interestingly, amelogenesis imperfecta was found, demonstrating a hereditary condition associated with comorbidities. Despite increasing oral pathology and wear into old age, good survival rates suggest biological resilience. The results of this study support resource-sharing practices regardless of developmental stage between sexes, as sAHGH retained homogeneous diets and labour-based contributions from childhood. This research contributes to holistic inferences on health and behaviour through the direct analyses of sAHGH, integrating biology with the environment, and elaborates on the discussion of the role of dental wear and behaviours contributing to pathology susceptibility. A macroscopic, multimethod approach proved effective in analysing the interplay of masticatory mechanisms and systematic assessments using non-destructive methods. These results demonstrated how hunter-gatherer groups thrived over millennia, and that sAHGH are a good adaptive representation of dental analyses for precontact populations.

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LIST OF ABBREVIATIONS

Abbreviation	Definition
AIC	Akaike's information criterion
AMTL	Antemortem tooth loss
BP	Before present
CEJ	Cemento-enamel junction
CI	Confidence interval
EH	Enamel hypoplasia
FDI	Fédération Dentaire Internationale
FEA	Finite element analysis
HGH	Hunter-gatherers and -herders
ISO	International Organization for Standardization
KZN	Kwa-Zulu Natal
MA	Middle-aged adult
M/OA	Middle/old adult
MRC	Marine reservoir corrections
Mya	Million years ago
OA	Old adult
OR	Odds ratio
ppm	Parts per million
sAHGH	Southern African hunter-gatherers and hunter-herders
SEM	Scanning electron microscopy
UCT	University of Cape Town
WHO	World Health Organization
YA	Young adult
Y/MA	Young/middle-aged adult

CHAPTER 1: INTRODUCTION

Dental anthropology is of great importance as the teeth can provide information otherwise not retrievable from the archaeological record. Teeth do not remodel unless influenced by intrinsic and extrinsic factors, as they are largely composed of inorganic materials. Due to the tooth's durability and lack of remodelling when damaged, the entire tooth preserves well ahead of the remaining skeleton. Directly examining the teeth may elucidate individual and population-wide diet, health, and behaviour. Such inferences can involve individual habits (bruxism, tool-use) (Burnett, 2016), population-wide habits (diet, tool-use, available resources) (Górka, Romero & Pérez-Pérez, 2015), cultural practices (weaning age, hygiene practices) (Oxilia et al., 2017), nutritional adequacy (fluoride levels, food choices) (Humphrey et al., 2014), and food preparatory habits (cooking, processing) (Grimoud & Gibbon, 2017). Utilising the teeth’s exposure to the elements as a model for direct interaction between people and their environment allows for the evaluation of potential factors that influenced an individual’s dentition in the past. Thus, when examining dentition holistically, the mutual influence of environmental and cultural variables is considered.

Southern African hunter-gatherers and hunter-herders (sAHGH) are integral to anthropological research. Morphologically, they are small-bodied and their teeth are microdont, placing them at an extreme of the range of human variation (Black, 2014) as determined by quantitative measurements of maximal mesio-distal and maximum labio-lingual diameters of the crown (Drennan, 1929; Van Reenen, 1964, 1966). The topography and climate of southern Africa varied greatly during the Holocene (≤11,700 years) largely affecting regional resource availability and determining the resultant sAHGH lifestyle. Understanding the changes and limits of the southern African landscape and its inhabitants’ adaptations is possible through drawing inferences directly from their biological characteristics. To date, past sAHGH lifeways are relatively well understood due to a plethora of multidisciplinary contributions from archaeological, bioarchaeological, and ethnographic research (Schapera, 1930; Shaw, 1931; Schapera & Farrington, 1933; Sampson, 1974; Tobias, 1978; Lee, 1979; Klein, 1984; Van Reenen & Briedenhann, 1986; Morris, 1992a; Soodyall & Jenkins, 1992; Bousman, 1998; Churchill & Morris, 1998; Sadr, 1998; Sealy & Pfeiffer, 2000; Mitchell, 2002; Stock & Pfeiffer, 2004; Pfeiffer & Sealy, 2006; Pfeiffer, 2007; Pfeiffer & Harrington, 2011; Black, 2014; Schlebusch et al., 2017; Gibbon & Davies, 2020). Fragmentary remains have limited many studies due to the chronological age of archaeological sAHGH skeletons, which often resulted in smaller samples, and much of the dental research has focused on site-specific comparisons (Sealy et al., 1992; Sealy, 2006; Irish et al., 2014; Pfeiffer et al., 2019). In cases where dental studies included larger samples, aims often revolved around odontometrics (Irish, 1993; Black, 2014) or contemporary samples (Drennan, 1929; Van Reenen, 1964, 1966; Morris, 1984; Van Reenen & Briedenhann, 1986; Morris, 1992a; Van Reenen, 1992; Irish et al., 2014; Botha & Steyn, 2015, 2016), yet the literature has not addressed systematic analyses of dental wear and oral pathology of archaeological sAHGH. Therefore, the nature of this dissertation involves systematic dental anthropological analyses on a large sAHGH sample, inclusive of individuals that are sexed and aged, radiocarbon dated and undated, and from coastal and in-land environments. Through the examination of dental macrowear quantity and direction against several independent factors, I explore possible variations in how sAHGH teeth reflect patterns in use-wear caused by various factors, including dietary and cultural habits. I also assess oral pathology to understand health, dietary habits, and possible behavioural patterns within distinct spatiotemporal environments of sAHGH individuals. Due to roles that dental wear plays in predisposing the teeth to further pathology (Kaidonis, 2008), it is deemed necessary to integrate these lines of evidence to discuss the multifactorial nature of sAHGH dentition. This study addresses questions regarding the past lifeways of sAHGH individuals throughout the Holocene whilst placing itself in a larger context against previous research on global hunter-gatherer and -herder (HGH) lifeways. By integrating biology and the environment using teeth, we can better understand the lifeways of the oldest genetic lineage of modern humans.

1.1 A note on terminology

As part of this thesis, several key terms require clarification. The term ‘precontact’ refers to the period in southern Africa before 1652 CE when European colonists began settling, initiating a dramatic change in the socio-political atmosphere and sAHGH dynamics (Adhikari, 2010). This selected term replaces ‘prehistory’, which connotes periods before the use of written records and often appears in research from colonised nations (Fredericksen, 2000). Some researchers argue that the word ‘prehistory’ and its multiform can convey the sense that cultures before colonisation lack a prior history in the colloquial use of the term, thereby attributing a lack of authenticity to it (Taylor, 2008), and scholars are increasingly debating the boundaries of human time and terminology (Fredericksen, 2000) in recent decades.

When the term ‘contemporary’ defines populations, it refers to any group of people that did not maintain a lifeway related to HGH strategies, for instance, agricultural, industrial, and post-industrial populations. Where it is necessary to speak about a ‘contemporary’ lifeway in isolation, the group will be regarded using the terminology of which the literature defines them (e.g., agriculturalists). ‘Contemporary’, when used in conjunction with related terms to research (i.e., contemporary research/studies/literature), implies research from the last two decades, distinguishing older and recent studies.

The tripartite chronological sequence of the southern African Holocene demarcates three terminological divisions: earlier, middle, and later Holocene, discussed in greater detail in Chapter 2. Researchers created these divisions from sAHGH technological advancements, evolving industry complexes, and subsistence strategies, and they are presently relevant in sAHGH literature (Stynder, 2006); therefore, this thesis includes this terminology.

In keeping with the philosophical paradigms emerging in southern African research (Forssman, 2019), this thesis uses a more general term for precontact southern African indigenous residents: southern African Hunter-Gatherers/-Herders or sAHGH. Southern Africa has a complicated history concerning standardised classification systems for the people of focus within this dissertation. Moreover, defining individuals and groups has been complicated due to the history of colonialism in southern Africa and resultant institutionalised discrimination (Adhikari, 2010), further upheld by the apartheid regime (1948-1994) (Clark & Worger, 2019). The literature generally defines resident southern African indigenous groups as ‘San’ for hunter-gatherers, ‘Khoekhoe’ for hunter-herders and ‘Khoesan’ for co-mingled groups (Smith, 1990). However, there has been a resurgence of interest in the social concepts behind sAHGH lifeways and their nomenclature (Forssman, 2019). In 2019, the San Council of South Africa established the preferred designation ‘San and/or Khoe’ for discussions with and of contemporary communities, suggesting appropriate nomenclature is still under debate. For this thesis, however, names of precontact southern African inhabitants derive from nomenclature not rooted in colonial influence (i.e., sAHGH), and only those without a history of colonial contact are included. A concern with equating archaeological data with cultures named after ethnographic groups has been raised by Pargeter (2016), and as Forssman (2019: 63) cites from Wadley (1989), we must abandon ‘primordialist’ perspectives by assuming precontact sAHGH “are merely fossilised San”, when contemporary San and/or Khoe groups reflect current socio-political conditions and recent historical events (Adhikari, 2010). In choosing sAHGH, I hope to individually represent the precontact, indigenous inhabitants that uniquely reflect southern Africa. In addition, due to the subject matter of this dissertation which includes archaeological remains that have been extensively studied in other research, the terminology of previous literature may be used only to clarify discussion where necessary.

Regarding other redefined southern African populations, the independent term ‘Bantu’ has discriminatory connotations from policies instilled by the apartheid regime (Tawha et al., 2020). This clarification is relevant as the external peopling of southern Africa through Bantu-language speaker migrations from 2000 BP, mainly to the eastern side of the country, initiated the agropastoral Iron Age of southern Africa, co-existing with sAHGH groups (Choudhury et al., 2021). Although this thesis does not directly examine precontact Bantu-language speaker agriculturalists, where it is relevant to mention in association with this study, the term ‘Iron Age agropastoralists’ will be used.

The FDI World Dental Federal notation system, typically referred to as the ‘FDI notation system’ or ‘ISO 3950 notation’, is a tooth numbering system used predominantly in figures within this thesis and is demonstrated in Chapter 3, although terminology pertaining to particular tooth types (e.g., upper right first molar) are also used for in-text clarity. The Fédération Dentaire Internationale developed the system (FDI), further appointed by the International Organization for Standardization (ISO), and the World Health Organization (WHO) approves and utilises the system (ISO 3950, 2016). FDI notation is necessary, as it provides a two-digit identification number for each tooth, automatically providing information on the tooth type, dental arcade, side, and precise location within the quadrant based on this number. This system remains the leading standard across dental fields, and dental experts have used it in dental research for decades (Grimoud et al., 2012).

1.2 Theoretical frameworks

Reconstructing the past in bioarchaeological studies comes with various theoretical and philosophical considerations. Researchers rely on fragmentary remains to recreate a narrative about the past, and humans are highly complex both in today’s world and within past populations (Wood et al., 1992; Zuckerman & Armelagos, 2011; Zuckerman & Martin, 2016; Buikstra et al., 2022). As a result, the multitude of social, political, environmental, and biological dimensions that play a role in bioarchaeological interpretations must be acknowledged and applied in current and future research (DeWitte & Stojanowski, 2015; Buikstra et al., 2022). The following general aspects are encompassed by considering theoretical approaches in bioarchaeological studies such as biocultural models and the osteological paradox: transdisciplinary thinking, reducing biased interpretations, perspectives on larger social and political processes, inequality and its intra- and inter-group prevalence, and weak population representation and interpretations.

The biocultural approach

The biocultural approach has a central role in developing the bioarchaeological discipline. Definitions of biocultural models have evolved over the 20th and 21st centuries; however, recent literature defines its greater purpose as an approach that "explicitly emphasizes the dynamic interaction between humans and their larger social, cultural, and physical environments" (Zuckerman & Armelagos, 2011: 20). Designing research with biocultural models in mind encourages the application of a conceptual framework that acknowledges dynamic interactions between the environment and human biology, in the form of phenotypic, psychological and sociocultural contexts (McElroy, 1990). Using a biocultural approach allows for an understanding of phenotypic plasticity and acts as an integrative intellectual approach within anthropology, broadening how researchers form questions around the biology of an individual and their surrounding context (Zuckerman & Martin, 2016). The application of a biocultural model is possible through linking interpretations and the resultant discussions about aspects that make up a human, including the diversity behind behaviours (e.g., source of violence) and relationships between subsistence strategies, economic variation, resource availability, access to resources, social stratification, and immune responses in a single environment (Buikstra et al., 2022). Utilising the approach has succeeded in researchers constructing more effective theories on human/environment relations and how both aspects alter and adapt to each other (Hoke & Schell, 2020). Notably, there are limitations to bioarchaeological data for reasons that may include: fragmentary remains, a lack of population-specific methods for age and sex estimation, and a lack of information on provenance or individual chronology (Buikstra et al., 2022), which further serves as purpose to apply a framework that considers the multifaceted nature of past interactions. Therefore, a biocultural model cannot be exactly replicated between studies but includes shared aspects that a researcher should consider when assessing and contextualising their data (Figure 1.1).

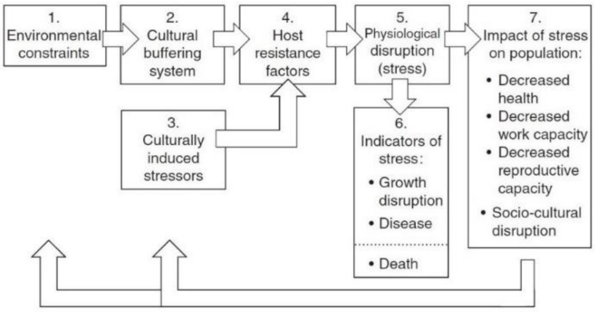


Figure 1.1: Biocultural model example by Zuckerman and Martin (2016: 12) identifying common aspects of consideration when interpreting data using a biocultural approach.

Humans are complex and have exhibited various cultural traits, such as communication styles, ideas, and intra- and inter-individual behaviours that ebbed and flowed over longer chronological periods (Pargeter et al., 2016), despite possibly having similar diets or upbringings. As a result, the biocultural approach contextualises this individuality and resultant responses to larger environments (Zuckerman & Martin, 2016). Challenges and developments to the approach are inevitable, but discussions such as that of Buikstra and colleagues (2022) about the changes prevalent and required in the field of bioarchaeology can help mitigate disciplinary challenges.

The osteological paradox

Wood and colleagues (1992) published a paper introducing the osteological paradox, discussing fundamental conceptual problems in osteoarchaeological assessments and subsequent interpretations for population-level studies. Ultimately, fundamental problems arise from bioarchaeologists attempting to reconstruct past lifeways by using biased samples that uniquely represent the deceased (DeWitte & Stojanowski, 2015). Before the publication in 1992, earlier studies risked assuming entire populations to be generally stationary and uniform as the provenance and characteristics of the deceased represented the health status and movements of the living, and the osteological paradox conceptually challenged these assumptions (Wood et al., 1992). Since its publication, the osteological paradox has incited numerous responses and over 1700 citations (Buikstra et al., 2022), further demonstrating the fundamental nature of the theory.

Wood and colleagues (1992) identified three paradoxical challenges in the original publication: (1) demographic non-stationarity, (2) heterogeneous frailty, and (3) selective mortality. The first paradox, demographic non-stationarity, implies that assemblages with evidence of migration or population movement will always demonstrate non-stationarity or movement represented temporally as changes in fertility and mortality. This concept is applicable as changing populations are considered to never be stationary. This ‘inevitable’ movement suggests that even a slight change in fertility may significantly impact the distribution of age at death, whereas a comparatively substantial change in mortality may not have any effect on age distributions. Therefore, the paradox suggests that observations on life expectancies or mean age in a sample would be measurements of fertility over mortality. Heterogeneous frailty considers skeletal samples probably do not represent all living populations, as the risk of death between individuals of the same age may vary due to differences in biology, behaviour, nutrition, and environment; therefore, the population should be heterogeneous for frailty. Selective mortality refers to heterogeneous frailty and acknowledges that one can only examine the deceased with available remains in a bioarchaeological study. Therefore, any resulting interpretations, most often related to health and demographic phenomena, are based on what remains are uncovered for the population. Consequently, interpretations may not be representative of the entire living population. The authors published the osteological paradox as a word of caution to researchers to be wary of using select individuals as direct measures for population-level inferences (Wood et al., 1992).

Since the creation of the osteological paradox, studies such as Wright and Yoder (2003), DeWitte and Stojanowski (2015), and Buikstra and colleagues (2022) have assessed and discussed its development and persisting relevance in the field of bioarchaeology. Throughout these papers over the past two decades since the original publication by Wood and colleagues (1992), considering the paradox when contextualising data reduces the threat of fundamental issues of population misrepresentation based on osteological assessments. A thorough understanding of the various conceptual challenges is integral to contemporary bioarchaeological interpretations. The paradox should be engaged when assessing data through good research design and expression of caveats or limitations, which are inevitable in bioarchaeological studies due to fragmentary remains, applying population-specific osteobiographical assessments on different populations, or lack of chronological control in a particular assemblage. These considerations encourage better contextualisation and representation. Considering this thesis includes aspects of health and behaviour, attempting to contextualise intra- and inter-site relations, as well as associating stress with demographic phenomena, acknowledging the aspects is only possible through the combination of multiple discourses and methods, and this section has highlighted the importance of acknowledging the theoretical impacts as presented by the paradox.

Historical biases in bioarchaeology

As biological archaeology arose in the 18th and early 20th centuries, researchers were little concerned with culture or history, and there was an apparent fixation on racial typology, frequently in the form of cranial morphometric studies (Zuckerman & Armelagos, 2011). This fixation on cranial morphometrics has also been highly evident in southern African bioarchaeological research, notable in studies from the 18th to early 20th centuries (Broom, 1923, 1941; Drennan, 1929; Van Reenen, 1964). Following 1994 and the fall of apartheid, the prevalence of scientific racism, namely by groups interested in pushing their policies and practices, began as a source of discussion (Dubow, 1995). Dubow (1995) challenged a post-apartheid academic world in southern Africa by investigating scientists' roles in being agents to the development of racial science. In line with these discussions, over the years, biological archaeology has grown as a global discipline, and the gap between other humanistic archaeological and biological anthropology disciplines to reduce as research began acknowledging biases reflective of global, current events. Nonetheless, a historical obsession with 'race' in the discipline remains a critical topic today, where the American Association of Biological Anthropology (AABA; previously American Association of Physical Anthropology) published a statement in 2019 critiquing the avid use of race as a representation of human biological diversity and a biological concept (AABA COD subcommittee, 2019). Perspectives on larger social and political processes began to be a part of discussions around bioarchaeological interpretations and findings in the 1980s and 1990s, giving rise to post-processual archaeology, which directed attention to social inequalities and their role in humans and their behaviour and adaptations. An emphasis on the factors that affected humans and how they manoeuvred their environments have since grown integral to the field of bioarchaeology, and now the field has gained perspectives on political, social, and economic contexts, as well as social inequalities such as gender and violence through the implementation of a biocultural approach (Zuckerman & Armelagos, 2011; Buikstra et al., 2022).

The relevance of bioarchaeology, with increased efforts in public engagement, bridges gaps between academia and the public by reconstructing the past through interpretations of dynamic interactions of ancient peoples with their environments, enabling people today to understand the lives of those who came before them. Theoretical considerations transformed and continue to transform the discipline, improving transdisciplinary thinking to provide interpretations that consider aspects such as individual identity, the impacts of health and stress, and by reducing challenges that may misrepresent a past population.

1.3 Thesis layout

This dissertation contains eight subsequent chapters. Chapter Two ('Background and Literature Review') reviews current methods and literature within dental anthropology and provides an archaeological background for southern Africa. Dental anthropology commences the chapter in the context of its history and applicability to contemporary research and its possibilities regarding inferences on precontact remains. The background sections compile archaeological, ethnographic, and bioarchaeological literature to illuminate current, relevant discussions on HGH and sAHGH research. The chapter is concluded with the study rationale and aims and objectives. Chapter Three ('Material and Methods') outlines the framework of this study by addressing parameters to demographic variables, including spatial and temporal demarcations. This chapter presents the inclusion criteria for individuals in the study sample and the methods employed to complete this research.

Chapters Four to Six present results and discuss individual main findings from their respective chapters. These independent chapters compose the overall study results with individual discussions. They are divided into three parts, as each included assessment is largely multifactorial and should be addressed independently and in combination with other variables, mainly individual tooth types and demographics. Chapter Four ('The Sample Results and Discussion') presents the sample distribution and discusses sampling biases that require further consideration. Chapter Five ('Dental Macrowear and non-Masticatory Wear Results and Discussion') presents an optimised Brabant index dental wear scoring method I created to improve methodological reliability and reproducibility, followed with macrowear quantity and direction results and discusses wear as an independent process against demographic factors. Lastly, Chapter Six ('Oral Pathology and Notable Features Results and Discussion') presents results on oral health and other conditions, which are then discussed independently against demographic factors.

Chapter Seven ('General Discussion') consolidates the results and discussions from the previous three chapters and provides a comparative review of all findings assessed whilst comparing them to other global archaeological studies. This chapter summarises the main findings by detailing the implications of sAHGH dental anthropological research and its relevance for southern African and global understandings of HGH lifeways. This dissertation concludes with Chapter Eight ('Conclusions'), including closing remarks, a novelty statement, and future research recommendations.

I initiated this research due to the necessity for a systematic dental study on dental macrowear quantity, direction and oral health conditions for archaeological sAHGH. Wear direction, as a methodology, had not yet been addressed for sAHGH teeth, where global studies have noted additional variations that were otherwise unreported until authors incorporated both wear quantity and direction, especially against oral pathologies (Lucas et al., 2011; Gibbon & Grimoud, 2014; Esclassan et al., 2015; Grimoud & Gibbon, 2017).

CHAPTER 2: BACKGROUND & LITERATURE REVIEW

This chapter encompasses a background and literature review on relevant subject matter for this thesis. As dental anthropology is the main focus, this chapter commences with a broad overview of dental anatomy, dental wear, and associated macro- and microwear methodologies. The history and structure of the Brabant index, a dental wear method which made this study possible, is then discussed. The subsequent section includes background information on several oral pathologies critical to the thesis methodologies. The following sections include background information on global HGH, a brief history of the developments of the subfield of HGH archaeology, and an archaeological background on the complexities of HGH societal structures. The subsequent section is a background on sAHGH through diet, behaviour, and ecology, providing a context to sAHGH livelihood throughout the Holocene. A broad summary of dental studies on global HGH populations follows, including their pertinence in contemporary research and aspects a researcher can glean, concluded with a thorough appraisal of sAHGH dental literature. This chapter concludes with a study rationale and the aims and objectives behind the conception of this work.

2.1 Dental anatomy

A complete permanent dentition consists of thirty-two teeth divided equally from the midline into four quadrants: the upper right, upper left, lower right, and lower left, each quadrant with eight teeth. The anterior (front) teeth include eight incisors with sharp crowns designed to cut and shear, and four canines, which are conical and also designed for shearing. The posterior (back) teeth include eight premolars built for chewing; and twelve large molars used for crushing and grinding food (Hillson, 1996; Górka, 2016). Each tooth type has a different morphology to assist its purpose. Compared to the single-cusped anterior teeth, the multicuspid posterior teeth become more complex. The maxillary (upper) premolars typically have two cusps, and the mandibular (lower) premolars may have up to three cusps, a dominant buccal cusp, and one or two lingual cusps. Maxillary and mandibular molar cusp number and terminology differs; however, both typically possess at least four main cusps (Górka, 2016). Molar cusp patterns are the most unique (Górka, 2016) and are of great use in dental wear studies as wear patterns can be distinct on the occlusal (biting) surface (Bartholdy, Hoogland & Waters-Rist, 2019). Teeth are beneficial in bioarchaeological studies as they are highly inorganic in form and do not remodel once they are damaged or worn away (Mays & Pett, 2014). Approximately 92% of enamel consists of hydroxyapatite, 6% of water, and 2% of organic matter, which makes it the hardest biological substance in the body (Zenobio, 2008). Dentine lies beneath the enamel and supports the enamel in protecting the pulp chamber, composed of 47% hydroxyapatite, 23% water, and 30% organic matter (Zenobio, 2008). As teeth are the only skeletal body directly interacting with the environment, they undergo several processes that are both mechanical and physiological. These aspects are discussed in more detail below.

2.1.1 Dental wear

Dental wear is a gradual process that occurs with age, where dental tissue from the tooth surface wears away due to an interplay between three general mechanisms: attrition, abrasion and erosion (Lee et al., 2012). Attrition transpires from tooth-on-tooth contact and most frequently results from the everyday mechanical function of the mouth, such as chewing food or grinding teeth (bruxism) (Burnett, 2016). Attrition is a loss of surface detail on the occlusal surface but can also appear on the interstitial surface when adjacent teeth rub against each other (Lee et al., 2012), and the level of attrition is generally related to occlusal load and masticatory force (Mays, 2015) and may differ between sexes (Littleton et al., 2013; Botha & Steyn, 2015), dietary choices (Smith, 1984; Górka, Romero & Pérez-Pérez, 2015), or parafunctional habits (Hattab & Yassin, 2000; Lee et al., 2012; Burnett, 2016). Attrition prevalence depends on the plane of attrition or the chewing cycle. Typically, as the teeth occlude and an individual chews, the intercuspal phase is initiated, further grinding maxillary and mandibular occlusal surfaces. (Figure 2.1) (Górka, 2016). As a result, most studies concentrate on attrition associated with diet, as the required masticatory force will vary depending on the food composition (Mays, 2015). For example, tougher and fibrous foods such as unprocessed meat or plant foods, which are relevant in HGH diets, require a stronger force as opposed to softer, processed foods, relevant in contemporary populations who refined ingredients by grinding or cooking into finer or softer consistencies (Scott & Winn, 2011; Mays, 2015). Furthermore, wear direction, or the defining patterns or gradients (characteristics) of the wear, depends on the occlusal surfaces varying degree of inclination (Smith, 1984).

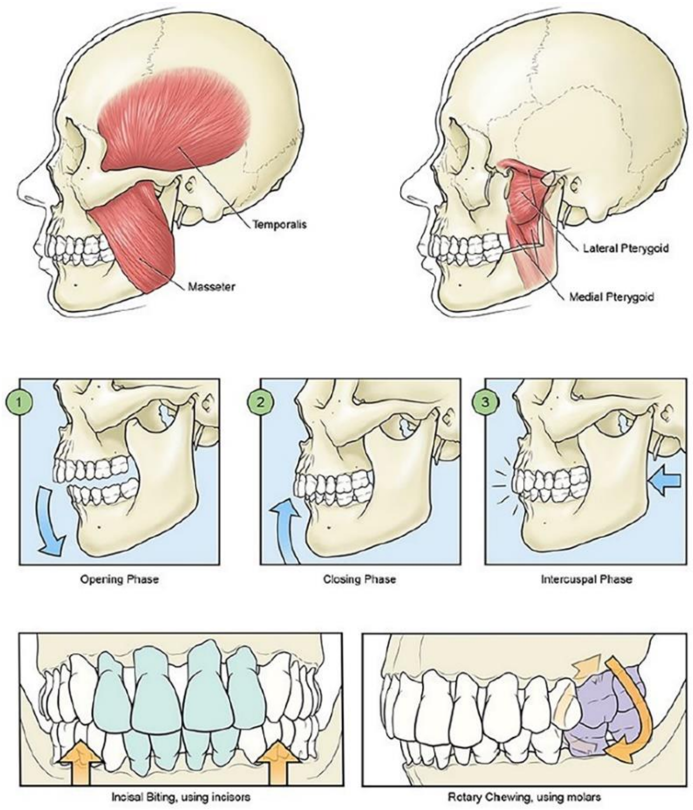


Figure 2.1: The chewing cycle featuring relevant muscles involved. Phases 1 and 2, puncture-crushing phases, do not involve tooth-on-tooth contact. Phase 3, the intercuspal phase, is a rotary movement involving attrition interactions between the teeth (Górka, 2016: 15).

Abrasion occurs with the addition of exogenous and abrasive material forced between the occlusal surfaces (Lee et al., 2012). This type of wear typically exhibits a concave, or 'scooped out', surface and can be demonstrated by uneven wear (Kaidonis et al., 2012). Like attrition, the extent of abrasive wear will depend on food composition and whether abrasive components contaminate the food through processing techniques, such as the use of grindstones (Kaidonis, 2008) or environmental particles, such as soil or sand (Forshaw, 2015). Erosive wear is an effect of the chemical dissolution of the entire tooth due to exposure to acidic agents identified by a lack of corresponding wear on the occlusal surface, as opposed to isolated wear locations on the surface from tooth-on-tooth contact (Coupal & Sołtysiak, 2017). This process is more prevalent in contemporary societies due to the high frequency and regularity of acidic product consumption (e.g., soda, alcohol, vinegar, and fruit juices) (Kaidonis et al., 2012; Coupal & Sołtysiak, 2017). Erosion may also be caused intrinsically by chyme (gastric fluid) from vomiting (Coupal & Sołtysiak, 2017).

Wear patterns across the dentition can vary due to varying tooth morphology, particularly in multicuspid teeth (posterior teeth). The molar teeth have the most complex cusp patterns and may present dentine exposure on a tooth, say in a ‘concave’ shape, while the remaining occlusal surface simultaneously presents alternative wear patterns such as enamel polishing with a flat wear direction (Hillson, 1996). The premolars are the most variable, to the extent that some early wear studies modified their methods to exclude the premolars (Molnar, 1971; Brothwell, 1981; Molleson & Cohen, 1990), although recent studies have argued their reintegration to improve wear observations and sample sizes (Bartholdy, Hoogland & Waters-Rist, 2019; Olszewski, 2019). When exposed to rapid wear environments, premolars wear much slower than other posterior teeth (Sperber, 2017), resulting in a flattened surface lacking surface detail (Burnett, Irish & Fong, 2013). Typically, wearing begins at the buccal cusp tips and will be apparent in the reduced lingual cusp. Once both cusps present exposed dentine, the remaining crown will wear away, demonstrated by different patterns of wear. Examples include peninsulas of enamel left in the grooves, breached crests of ridges with dentine exposure, and between cusps for example, advanced wearing on a larger buccal cusp, with little to no polishing on the lingual cusp. The opposite may also happen with this wearing process (Hillson, 1996).

Dental wear first occurs on the incisal edges or tips of individual cusps. Eventually, isolated wearing areas spread onto the entire occlusal surface, destroying the enamel or crown (Benazzi et al., 2008). Teeth with heavier occlusal loads wear faster and on regions of certain teeth, such as the mandibular molar buccal cusps, which take the brunt of masticatory load (Mays & Pett, 2014). Because teeth are mechanically anisotropic (Mays & Pett, 2014), understanding wear across the dentition gives insight into how the tooth the regular loss of the tooth substance over time.

2.1.1.1 Dental wear scoring methods

Dental wear analyses classify under two categories: microwear and macrowear. Both help elucidate aspects of what the teeth have been exposed to throughout a lifetime by observing wearing characteristics. Researchers designed different recording systems to distinguish between the physiological origins of the wear, its quantity, and how to interpret its characteristics. This section reviews the history of relevant dental wear scoring methods.

Microwear

Microwear markers are microscopic traces on the tooth surface from processes related to masticatory forces, diet, and tool-use (El-Zaatari, 2010). Butler and Mills (1959) were the first to investigate subparallel striations on molars, evidence of jaw movement and direction, which launched the subfield of microwear analysis. Microwear considers abrasive particles to be equivalent or to have increased hardness as the enamel matrix, and through the observation of microscopic pits and scratches, a detailed examination of specific factors that affect the type and rate of dental wear can be executed (El-Zaatari, 2010). Hard abrasive particles compressed into a tooth's enamel, for instance, may cause pits on the surface. This results in cracks within the enamel's crystalline structure, fracturing minute fragments from the surface. In contrast, scratches are caused by particles dragging between opposing tooth surfaces during chewing (Kaidonis, 2008). Microwear analysis evaluates the wear facets, the cusp tips for crushing and cuspal slopes for shearing, to determine the characteristics of consumed foods. Harder foods require greater masticatory forces, thus, resulting in more numerous and larger pits, while softer foods exhibit more scratches (Forshaw, 2015).

Early microwear techniques used conventional optical light microscopy; however, methodological developments were slow due to a limited depth of field and power; thus, newer equipment rapidly replaced this technique (Ungar et al., 2008). Scanning Electron Microscopy (SEM) became the subsequent and most common technique used in microwear studies (Khan, Young & Daley, 1998; Ungar et al., 2008). In the early stages of SEM microwear research, the techniques characterised dietary habits in animals (i.e., mammals) as opposed to humans, as seen through studies by Puech (1979), Ryan (1979) and Walker (1981). As technological advancements developed, contemporary studies discovered alternative techniques such as light confocal microscopes (Scott et al., 2006), intra-oral optical imaging (Meireles et al., 2016) and cone beam computed tomography imaging (Maret et al., 2011; Koh et al., 2017). Notably, microwear analyses are employed less frequently than macrowear as the techniques require specialised equipment and expertise; thus, they are not time, user-, or budget-friendly. Moreover, the methods are not practical for holistic analyses on large sample sizes and are limited in their applicability.

Macrowear

Macrowear occurs over time from persisting microwear and involves macroscopically visible wear (Schmidt, 2018). Approaches to wear analyses date as far back as the 1800s, with the most referenced work from this period published by Broca (1879). The author created a qualitative method that recorded wear via a gradually increasing four-stage scale of enamel loss up to the cementoenamel junction (CEJ). This method became the template for qualitative dental wear scoring. Following Broca's method, Murphy (1959a,b) developed the next most widely recognised recording system. Instead of enamel loss, Murphy (1959a,b) used dentine exposure to score macrowear into eight stages. This system became the technique that many later studies used as a template for creating new scoring methods. Miles (1963a,b) modified Murphy's (1959a,b) method, by considering the time of tooth eruption to demonstrate individual and population-wide variation. Over the following decades, recording systems grew more complex as other researchers began refining them for reproducibility and accuracy.

Macrowear methods developed as researchers continued to create macrowear recording systems that took new approaches. Scott (1979), for example, divided the occlusal surface of the molars into quadrants and scored them using a ten-stage system. Gustafson and Malmö (1950), Johanson (1971), Brothwell (1981), and Lovejoy (1985) developed this further, with additional reference to Murphy (1959a,b) and Miles (1963a,b), by reporting on the gradual process of dental wear for age-at-death estimation. Quantitative methods began to develop because of Smith (1984), who revised the method by Murphy (1959a,b) for reproducibility whilst also quantifying scoring methods by examining the angle of wear on molars between HGH and agriculturalists. Smith (1984) determined a rate of wear relative to the angle of wear from the original height of the occlusal surface. This method's benefits were two-fold in subsequent studies (Mays, de la Rua & Molleson, 1995; Benazzi et al., 2008), as it opened doors for age estimation using crown height to calculate enamel loss through measurement and exhibited new possibilities for quantified direction scoring. Although novel, quantification methods based on crown heights have since been criticised for higher subjectivity, as they estimate the loss of the occlusal surface height on a tooth whose primitive volume cannot be precisely determined (d'Incau, Couture & Maureille, 2012).

Macrowear direction and associated patterns began to be of interest in the literature, as the methods by Brabant (1966) illustrated, due to the possibility of wear direction to contribute behavioural and dietary data using non-destructive techniques (Chazel et al., 2005; Caglar et al., 2007; Esclassan, Grimoud, et al., 2009; Lucas et al., 2011; Gibbon & Grimoud, 2014). Wear direction methodologies provided information on crown wear between different lifeways, such as HGH and agriculturalist diets (Smith, 1984; Forshaw, 2015). For example, abrasive contaminants demonstrated 'concave' wear directions, frequently observed in groups inhabiting a coastline (Van Reenen, 1992; Forshaw, 2015), or used tools that contaminated an ingredient during processing, such as mineral contaminants from ancient Egyptian soft sandstone grinding tools to grind grain (Forshaw, 2009, 2015). Moreover, observations on direction and pattern provided information on masticatory function; for example, HGH exhibited flatter molar wear because the molars did not make frequent contact during mastication from the tough and fibrous nature of the food (Smith, 1984; Górka, 2016). With the increasing prevalence of prepared or processed foods, the teeth made contact for extended periods with the increasing grinding and sliding against each other, resulting in oblique wear (Kaifu et al., 2003), as seen in agriculturalist dentitions (Grimoud & Gibbon, 2017).

Newer research has introduced many new methods since initial macrowear studies, and both qualitative and quantitative methodologies have grown in popularity due to their ease of application coupled with the amount of information they can provide on large samples. One of these methods as used in this thesis, the Brabant index, is well-known in the literature due to its inclusion of wear quantity and direction. A review of this method is provided below.

2.1.1.2 Brabant index

The Brabant index is a user-friendly, ordinal classification system introduced by Brabant (1966) that scores for macrowear quantity and direction and has been employed across numerous studies (Villa & Giacobini, 1996; Chazel et al., 2005; Caglar et al., 2007; Esclassan, Grimoud, et al., 2009; Lucas et al., 2011; Gibbon & Grimoud, 2014; Esclassan et al., 2015; Caglar, Görgülü & Kuscu, 2016; Grimoud & Gibbon, 2017; Singh Sehrawat & Singh, 2018; Nedoklan et al., 2020). The index uses a qualitative measurement system, presented through descriptive characteristics that record the total loss of dental tissue or wear quantity and the plane and physical attributes of the wear or wear direction. This index is unique as it includes macroscopic wear direction information, which the literature has not extensively studied (Esclassan et al., 2015). Using the index, a researcher can infer diet and food types through quantity assessment; and dietary and cultural habits, resource choices, subsistence transitions, and parafunctional habits involving the mouth through direction assessment.

Some studies are selective with the Brabant index in that only one wear attribute is scored (i.e., quantity or direction) (Chazel et al., 2005; Caglar et al., 2007; Caglar, Görgülü & Kuscu, 2016; Singh Sehrawat & Singh, 2018). These studies remain informative as they can demonstrate differences between sample populations, whether it be with the extent of wear between time periods (Chazel et al., 2005) and key elements of a diet such as a soft, non-abrasive diet (Caglar, Görgülü & Kuscu, 2016) or a hard and abrasive diet (Caglar et al., 2007). Of all studies that have used the index, results have elaborated upon the interplay between macrowear and other factors such as oral pathologies (Chazel et al., 2005; Esclassan, Grimoud, et al., 2009; Lucas et al., 2011); masticatory function (Mockers, Aubry & Mafart, 2004); gender-based division of labour (Gibbon & Grimoud, 2014); dietary factors (Chazel et al., 2005; Caglar et al., 2007; Esclassan, Grimoud, et al., 2009; Caglar, Görgülü & Kuscu, 2016; Grimoud & Gibbon, 2017; Nedoklan et al., 2020); sociocultural factors (Chazel et al., 2005), and non-masticatory use of the teeth (Gibbon & Grimoud, 2014; Singh Sehrawat & Singh, 2018).

Gibbon and Grimoud (2014) have conducted the only study using the Brabant index on southern African teeth, although with an Iron Age sample from Zambia. The population's lifeways were different to sAHGH regarding diet and food processing habits. However, the application of the index elucidated variations within wear patterns in southern Africa, such as a heavier quantity of wear on the anterior teeth, suggested to be from dietary choices and tool manipulation using the teeth. Conversely, wear direction exhibited changes between young and middle-aged adults, which may reflect general occlusal movements during mastication and increasing wear with age. Direction also elucidated gender-based differences, unlikely caused by diet, suggesting males and females used their teeth as tools for different activities (Gibbon & Grimoud, 2014).

Considering the amount of introspective information this index can provide, a researcher can prioritise larger sample sizes as the method is neither complex nor time-consuming to execute and thus is used in the present study. Additionally, analysing macrowear quantity and direction using the Brabant index has not yet been conducted on sAHGH, and its application may reveal insights into large-scale changes in diet and behaviour.

2.1.2 Non-masticatory wear

Certain behaviours can induce advanced or characteristic patterns in isolated or select teeth. Non-masticatory wear defines advanced wearing that can be affiliated with behaviours that involve the mouth (parafunctional habits), including the use of the teeth as a third hand, such as running fibrous materials through the teeth for thread wetting and sinew stripping (Erdal, 2008), wood shaping (Hylander, 2011), holding pins or nails between teeth (Bonfiglioli et al., 2004), pipe smoking (Olszewski, 2019; Velsko et al., 2022), or betel nut chewing (Koesbardiati, Murti & Suriyanto, 2015; Singh Sehrawat & Singh, 2018), and gradually result in distinct wear patterns such as grooves or notches (Erdal, 2008), isolated wear directions or lingual tipping (Kaifu et al., 2003), or dental fracturing (Bonfiglioli et al., 2004).

Intentional or decorative dental modification is a cultural phenomenon that includes the filing, chipping, incising, colouring, inlays, or evulsion of teeth for personal or group ornamentation (Stojanowski et al., 2016; Burnett & Irish, 2017; Arcini, 2020). Their presence and styles vary widely between individuals, communities, and geographic regions as the intentions may be cultural, religious, aesthetic, or used for identification purposes (Hrdlička, 1940; Morris, 1998; Friedling & Morris, 2005, 2007; Reichart, Creutz & Scheifele, 2007; Gibbon & Grimoud, 2014; Pinchi et al., 2015; Stojanowski et al., 2016; Pietrusewsky et al., 2017; Rufino, Ferreira & Wasterlain, 2017; Arcini, 2020). Researchers have observed intentional modification across most continents since the late 1800s and early 1900s (Hamy, 1882; Starr, 1909; Van Rippen, 1918; Shaw, 1931), and current literature still values observations on dental modification as it elucidates cultural behaviour (Pietrusewsky et al., 2017; Rufino, Ferreira & Wasterlain, 2017; Arcini, 2020).

Dental modification across southern Africa has taken many forms (Fagan, 1967; Van Reenen, 1978; Briedenhann & Van Reenen, 1985; Van Reenen & Briedenhann, 1986; Milner & Larsen, 1991; Jones, 1992; Morris, 1998; Friedling & Morris, 2005, 2007; Reichart, Creutz & Scheifele, 2007; Gibbon & Grimoud, 2014; Pinchi et al., 2015; Burnett & Irish, 2017), for example, Iron Age agropastoralists have demonstrated varying levels of dental modification, mainly in the style of anterior dental chipping during the Early Iron Age (300 – 900 CE) (Gibbon & Grimoud, 2014) or incisal evulsion (Walker & Hewlett, 1990). In contemporary HGH, Van Reenen and Briedenhann (1986) reported that the most typical style on the western edge of the Kalahari Desert in Botswana was filing the incisal teeth into blunt points ('Cokwe' style), also observed by Jones (1992) in Angola, along with an inverted 'V' shape in the upper and lower anterior teeth potentially due to intermingling between tribal borders (Jones, 1992). Notably, archaeological sAHGH dental studies have not observed intentional dental modifications, although Van Reenen (1964) identified an inverted 'V-shaped' notching in the central incisors of five male, farm-based San and/or Khoe individuals from contact periods. The author suggested the presence of this practice was through Iron Age agropastoralist influence.

The reasons behind the presence and type of non-masticatory wear may vary: tool use or parafunctional habits (Milner & Larsen, 1991; Erdal, 2008); and dental modification for religious and tribal traditions, aesthetic purposes, a rite of passage, adornment, tribal identification or a mark of punishment (Briedenhann & Van Reenen, 1985; Jones, 1992; Morris, 1998; Friedling & Morris, 2005). As such, sAHGH may present non-masticatory wear or dental modification, and markers should be diagnosed with care through evidence of a consistent and symmetrical pattern across the sample under study (Merbs, 1968). Oral pathology can further affect the visibility of non-masticatory wear and dental modification markers, and relevant oral pathology for this thesis encompasses the subsequent sections.

2.2 Oral health and pathology

In the early 1600s, the London Bills of Mortality listed oral diseases as the fifth or sixth leading cause of death, and the detrimental circumstances associated with dental disease, particularly with infectious lesions, were only formally addressed in the late 19th century, with the development of dental surgery (Calcagno & Gibson, 1991). Although dental disease may not always be fatal, many conditions are correlated with elevated mortality risks if left untreated (DeWitte & Bekvalac, 2010). Oral health is an incredibly interconnected system, where one issue predisposes the teeth to others (Hillson, 2008) and causes physiological stress, making a person more susceptible to secondary infection (Regezi, Sciubba & Jordan, 2017). For example, dental crowding may lead to impaction, caries, infectious lesions, and periodontal disease, predisposing the teeth antemortem tooth loss (AMTL) (Craddock & Youngson, 2004). Poor dental hygiene can result in calculus deposition, leading to caries, infection, abscess and consequently, AMTL (Hillson, 2008; Oxilia et al., 2017). Enamel hypoplastic defects can form following childhood episodes of physiological stress, weakening defected areas on the tooth surface, making them prone to demineralisation, and thus, caries and so forth (Rohnbogner & Lewis, 2016). Further yet, dental wear is considered a natural process and is not pathological by nature, yet it becomes pathological if the tooth is worn to the point of pulp cavity exposure (Kaidonis, 2008). Pulpal exposure is the most extreme stage of dental wear and predisposes a tooth to infection and likely AMTL, with a repeat in processes as further increased rates of wearing in the adjacent teeth occur as the remaining teeth bear the occlusal load (Mays, 2015).

Ultimately, the interrelationship of oral health conditions can be instigated by poor general health, resulting in even worse health, and factors such as diet, genetics, hygiene habits, and environmental conditions may further aggravate an oral environment (Hillson, 2008). This section reviews relevant oral pathology for this thesis, including AMTL, caries, infectious lesions, enamel hypoplasia (EH), and dental trauma, their aetiologies, and their pertinence in biocultural reconstructions.

2.2.1 Dental decay, infections, and antemortem tooth loss

Caries, infectious lesions, and AMTL are part of an interconnected system where the presence of one condition predisposes the teeth to another. Extensive caries reaching the pulp chamber renders the tooth susceptible to other infections, leading to the formation of infectious lesions and, potentially, eventual tooth loss either through periodontal disease (Temple, 2016) or extraction (Oxilia et al., 2017). The aetiologies of dental decay and AMTL can occur from oral chemical imbalances relative to diet, genetics, environment, and socio-cultural influences (Hillson, 2008; Kaidonis, 2008; Ritter et al., 2009; Temple, 2016).

Carious lesions develop relative to dietary composition and individual biology, and other conditions, such as calculus, may also instigate cariogenesis (Ritter et al., 2009). Calculus development begins with plaque, a softer, early state of calculus, and grows relative to micro-bacterial activity, consisting of food debris, salivary proteins, and micro-organisms (Mackie, Radini & Speller, 2017). Although the degree of micro-bacterial activity varies between people (Lieverse et al., 2007), there typically tends to be greater micro-bacterial activity in the absence of oral hygiene (Caselitz et al., 2013). However, factors such as dietary choices (e.g., highly fermentable products) and inter-individual imbalances (e.g., salivary acidity levels) may also contribute. Protein and complex carbohydrates produce alkaline waste products, whereas foods associated with higher acidity levels and sugar content are prevalent in refined carbohydrates (Hillson, 2001). Refined carbohydrates metabolise faster than protein and complex carbohydrates and, thus, produce higher levels of lactic acid that may instigate enamel demineralisation or cariogenesis (Temple, 2016). Although chemical balance relative to diet is the widely accepted theory on caries aetiology, researchers have suggested carious prevalence is further dependent on genetics, environmental, and sociocultural influences (Ockerse, 1943; Alvarez, 1995; Hillson, 2001, 2008; Chazel et al., 2005; Caselitz et al., 2013). Caries expression is instrumental in biocultural studies as its presence may provide an instantaneous idea of the individual's general diet and hygiene behaviour and can provide insights into the presence of other conditions, such as infectious lesions and AMTL.

Bacterial infection in the dental pulp of a tooth through trauma, or exposure by caries or dental wear, can develop an inflammatory reaction or an infectious lesion (Dias & Tayles, 1997). These lesions typically appear beneath the alveolus as granulomas and gradually develop into bony cavities known as abscesses or cysts if left untreated. Each type of infectious lesion has different characteristics that aid a researcher in identifying the type and degree of infection. However, because most infections first develop beneath the alveolar surface, it can be challenging to observe macroscopically until they break through the bone (Dias & Tayles, 1997; Dias, Prasad & Santos, 2007; Forshaw, 2014). Implications of present infection provide information about the systemic health of an individual throughout their life and elucidate additional dental problems such as tooth loss (Dias & Tayles, 1997), and in some cases of advanced lesions, provide information about additional complications such as septicaemia and death (Forshaw, 2014). AMTL occurs through four primary factors as outlined by Lukacs (2007: 157–158), "(1) variations in dietary consistency; (2) nutritional deficiency diseases; (3) cultural or ritual ablation; and (4) trauma." Variations in dietary consistency are complex because, on the one hand, they can include abrasive foods expediting pulpal exposure, thus, infections and tooth loss (Lukacs, 2007). On the other hand, diets of softer and refined foods, often higher in refined carbohydrates, are reported to predispose the teeth to carious lesions (Temple, 2016) and oblique wear (Gibbon & Grimoud, 2014), encouraging pulpal exposure. For example, the precontact Inuit diet was high in protein and fat from marine sources (e.g., seal, caribou, fish and walrus) (Kelly, 2013) and consumed little carbohydrates resulting in lower caries incidence (Hillson, 2008). In one study, Keenleyside (1998) reported a single carious tooth out of 1840 Inuit teeth, and Mayhall (1970) also reported less than one cavity per individual recorded in precontact Inuit individuals, until 20th century colonisation, when the diet increasingly included foods high in refined carbohydrates from newly established trading posts. Within a single generation, the caries figures rose to between 8 and 15 cavities per individuals, demonstrating significant results of associated caries prevalence with changing sociocultural aspects that altered a groups subsistence strategies, behaviour, and dietary choices (Mayhall, 1970).

When dental conditions are left untreated, the degenerative process expedites. AMTL and infections correspond with conditions that are an effect of diet (Lukacs, 2007); more often, it typically affects individuals in populations with high caries rates or heavy dental wear (Kieser et al., 2001; Lukacs, 2007; Hillson, 2008; Nelson, 2016). Several studies have discussed the correlation between caries and AMTL; however, the accurate reflection of caries prevalence relative to AMTL is a challenge in archaeological studies, as the physical loss of the tooth makes it impossible to reach a conclusive answer of its aetiology (Hillson, 2008). Some earlier studies attempted to rectify this issue through caries correction factors (Hardwick, 1960; Brothwell, 1963; Lukacs, 1995), ultimately calculating caries incidence and other oral pathologies only against physically present teeth.

2.2.2 Enamel hypoplasia

Unrelated to dietary components or the oral environment, EH occurs from a physiological disturbance in childhood, manifesting as isolated pits or bands of deficiency in enamel thickness on one or many teeth (Goodman & Rose, 1990; Hillson, 2008). EH occurs as pitting or horizontal furrows (lines) on the labial and buccal tooth surface, but defects can form enamel opacities or hypocalcification, which presents as a discolouration on the tooth surface. Following a physiological insult, the enamel crown matrix fails to form properly if enamel secretion is disrupted during crown development, resulting in a defective or incomplete formation in the crown (Schuurs, 2013). EH is notable in the literature as the location of the defect reflects the completeness of crown development at the time that a child endured the stressor (Hubbard, Guatelli-Steinberg & Sciulli, 2009). Within human palaeopathological literature, researchers examine and discuss EH because it is quantifiable (Lukacs, 1989; Goodman & Rose, 1990; Hillson & Bond, 1997; Tomczyk, Tomczyk-Gruca & Zalewska, 2012; Hassett, 2014) against enamel formation times (Reid & Dean, 2006). Developmental defects are a non-specific indicator of a stressful episode as they form a band (linear enamel hypoplasia or LEH) on the surface of the tooth crown, corresponding with the crown's growth interval (Hillson, 2008). The distance of this band from the cementoenamel junction (CEJ) is measured to trace at what age the disruption occurred (Hassett, 2014). EH is a symptomatic reflection of physiological stress (Goodman & Rose, 1990; Hillson, 2008), yet the precise aetiology of the disruption is difficult to discern, as hereditary and environmental factors can collectively instigate stressors (e.g., disease and malnutrition) (Seow, 2014). However, if EH is only prevalent on an individual tooth or a few teeth, the cause is likely local (Schuurs, 2013), whereas inconsistent defects in number and type are more likely a hereditary condition, such as amelogenesis imperfecta (Crawford, Aldred & Bloch-Zupan, 2007; Gadhia et al., 2012).

Localised regions of weakened enamel from EH reportedly predispose the tooth to sensitivity and greater susceptibility to carious development, wear, and erosion (Seow, 2014); however, Hillson (2001) reported a large-scale concern in past populations for localised susceptibility to other diseases is only as serious if the growth disruption is consistent throughout the population under study. This is due to the variation of defected enamel between the teeth involved, the timing of growth disruption, and the vulnerability of the crown surface to carious development. Ultimately, the prevalence of EH differs significantly between populations under stressful circumstances (Hillson, 2001). For example, high EH prevalence was found for Egyptian agriculturalists along the Nile River following inundation failure and resulting in drought and famine (Forshaw, 2015). Whereas Pfeiffer and colleagues (2019) reported little evidence of EH in sAHGH teeth between 3500 and 2000 BP, a period shown to have a population-wide reduced body size illustrating a biologically stressful period, further attributed to environmental stressors such as rapid population growth and resource competition (Sealy & Pfeiffer, 2000; Pfeiffer & Sealy, 2006; Kurki et al., 2010). Gibbon and Davies (2020) also discussed similar periods in South Africa regarding EH, and the authors associated this lack of evidence for physiological stress with greater biological resilience to stressors, demonstrating hereditary factors may play a noteworthy role in EH prevalence.

2.2.3 Dental trauma

Dental fracturing can elucidate accidental trauma or dental modification. Maxillary central incisors are the most frequently injured teeth in deciduous and permanent dentitions, likely due to the location being most vulnerable compared to the remaining dentition protected by the cheek muscles (Bastone, Freer & McNamara, 2000; Öztan & Sonat, 2001; Górka, 2016). Although several types of tooth fractures can result from trauma, such as crown fractures, root fractures, and luxations, crown fractures are the only type visible on the teeth without radiographic examination (Bastone, Freer & McNamara, 2000; Gibbon & Grimoud, 2014). Subluxations and complete luxations are prevalent in past hospital studies on contemporary individuals (Bastone, Freer & McNamara, 2000), yet archaeological literature has noted root fractures, such as in southern African Iron Age remains (Gibbon & Grimoud, 2014). Although studies caution that without radiographic examination, root fractures are rarely macroscopically visible unless the tooth is loose (Çobankara & Üngör, 2007; Gibbon & Grimoud, 2014). Clinicians confirm luxations through damage to the alveolar sockets and surrounding jaw (Bastone, Freer & McNamara, 2000), although poorly preserved remains and taphonomic damage to the alveolar sockets, maxillae and mandibles may significantly affect the visibility of such traumas, which makes them challenging to confirm in archaeological remains.

To distinguish between ante or postmortem fractures, an antemortem fracture should ideally retain the tooth in the jaw to infer evidence of pulp survival (Bastone, Freer & McNamara, 2000; Gibbon & Grimoud, 2014). Otherwise, an uncomplicated crown fracture (a microchip/superficial enamel chip), requires more care to identify (Scott & Winn, 2011). Dental trauma is observed via smooth edges of the fractured enamel, suggesting continued use of the tooth. The enamel typically cracks vertically and either superficially affects the enamel, falls clean off and reveals the dentine, or involves the dentine and falls away in an irregular shape (Bastone, Freer & McNamara, 2000). To discern a fracture from pathological to dental modification, a researcher should reference possible patterns as per past literature (Hillson, 2008), such as for southern Africa, the inverted 'V-shaped' notch in the anterior teeth as observed in ethnographic work (Van Reenen & Briedenhann, 1986). In any case, a high incidence of a recurring fracture type or selective tooth evulsion may demonstrate the presence of patterned dental decoration (Bastone, Freer & McNamara, 2000), as discussed earlier in Section 2.1.2.

2.3 Hunter-gatherers and -herders

Hunter-gatherers live a nomadic lifestyle and subsist through hunting animals and gathering resources (e.g., plants, shellfish, molluscs) available within the inhabited region (Hamilton et al., 2007). Hunting-herding defines the maintaining of a hunting-gathering lifeway but with the added component of tending animals or possessing livestock (Sadr, 2015; Kowner et al., 2019). HGH society's social organisation will vary between communities and should not be oversimplified (Hamilton et al., 2007). Below is a summary of the conception of global HGH intellectual frameworks and relevant aspects to consider when conducting HGH research.

2.3.1 The development and complexity of hunter-gatherer and -herder research

Research regarding HGH communities has been unique compared to post-agriculturalist societies, mainly due to stark differences between an HGH lifestyle and sedentary or industrialised communities. Academic research into HGH societies from the 1900s to the 1960s applied the 'Hunter-Gatherer Theory' to initial interpretations (Bettinger, 1987), largely based on 'primordial' claims (Forssman, 2019). Following World War II, from the mid-1960s and 1970s, this line of thought transformed, and perspectives on HGH communities grew more sophisticated with the introduction of 'new archaeology' (Bettinger, 1987), commonly recognised as 'processual archaeology' (Forssman, 2019). These new perspectives attempted to critically assess and evaluate the validity of past interpretations of archaeological remains through scientific theory (Forssman, 2019), which was not commonplace in archaeology (Binford, 1989). The approach was eventually absorbed in the mid-1970s by the emergence of 'post-processual archaeology', a movement that attempted to involve the concept of human agency in interpreting archaeological evidence, of which today's archaeological frameworks are shaped (Shanks, 2007). Other approaches gradually appeared, namely the 'optimal foraging theory' to model resource structures and foraging strategies (Winterhalder & Smith, 1981; Forssman, 2019), such as energy *versus* time (Churchill & Morris, 1998), and behavioural ecology, as behaviours may connect to ecological conditions (Humphreys, 2007).

In spite of developing intellectual frameworks, HGH researchers have become more knowledgeable of HGH society complexity in recent decades (Hamilton et al., 2007), and most research presents a group's behaviour based on its local context, with some global comparisons (El-Zaatari, 2010; Black, 2014; Górka, Romero & Pérez-Pérez, 2015; Romero, Ramirez-Rozzi & Pérez-Pérez, 2018), to better illustrate how a group behaves compared to an alternative context. Contemporary research has avidly encouraged the discussion of HGH societal structure complexity and the multidimensional aspects of HGH behaviour (Hewlett & Lamb, 2005; Kusimba, 2005; Hamilton et al., 2007; Gordon, 2009; Schrire, 2009; Johnson, 2014). This is because the flow of resources and underlying forces, such as social and environmental conditions, kinship or marriage, disease, and competition governed hierarchal structures, industrial complexes, and the implementation of new subsistence components (e.g., herding) (Hamilton et al., 2007). As a result, HGH studies include multiple lines of research and draw supporting evidence from archaeological, biological, material, historical, ethnologic, and ethnographic contexts to reconstruct past HGH societies. Despite the transformation of archaeological research and theory, the pioneering work of many researchers remains relevant today, as they often provide additional raw data required for comparative study; therefore, an evaluation of the literature discussing the commonalities and variabilities between global HGH communities comprises the subsequent sections.

2.3.2 Hunter-gatherer and -herder lifestyles and diets

Hunting and gathering, a symbiotic provision of plant and animal protein, appeared around ~2.5 Mya with the origins of the genus *Homo*, through evidence of cut-marked bones and tool use suggesting a growing reliance on strategically obtaining nourishment (Pontzer & Wood, 2021). These discoveries suggested a progressive behavioural distance from plant-heavy foraging of earlier hominins. As tools grew more complex and butchered faunal remains increased, it became apparent that hunted animals demanded special skills, strategies, or processing methods, such as large (Van Kolfschoten, Buhrs & Verheijen, 2015) or small and fast animals (Ben-Dor et al., 2011). The digestive system and nutrient pattern of humans evolved along with food processing strategies, which included controlled fire, stewing, drying, and curing (Milton, 2000). Physiologically, dietary energy density increased, which reduced the volume of food eaten on average per day (Simmen et al., 2017), and the dentition reduced considerably in size and number compared to the dentition of hominins and pre-modern *Homo* (Emes, Aybar & Yalcin, 2011; Evans et al., 2016). Additional oral morphological adaptations included less robust jaws as masticatory muscle attachments diminished with a growing reliance on food processing, and the canine teeth became less dominant (Clement & Hillson, 2013; Guatelli-Steinberg, 2016; Górka, 2016).

HGH group size and organisation depend on spatial and temporal variations in resource distribution because resources are harvested from the environment to meet metabolic needs (Hamilton et al., 2007). Globally, cultures practised two general subsistence strategies: 'immediate-return' or 'delayed-return'. An immediate-return system emphasises the imminent consumption of hunted or foraged foods without an intention to store the product (Kusimba, 2005). A delayed-return system involved intentional delayed subsistence, such as subsurface storage of gathered foods (Deacon et al., 1978), drying or curing meat or fish (Costa, 1980), using livestock for a steady supply of a resource (e.g., milk) (Deacon, 1984), or in later societies, planting crops and waiting for harvest (Hewlett & Lamb, 2005).

HGH subsistence strategies require time and energy; hunting is strenuous and attributed to risk, but if successful, it has a high reward (Pontzer & Wood, 2021). Foraging also consumes moderate energy (Gallois & Henry, 2021) but is a reliable strategy as it is typically more successful, albeit the foods may not always be as rich in energy (Pontzer & Wood, 2021). By nature, HGH diets greatly depend on accessible resources; therefore, the balance or general presence of plants to meat to fish varied considerably across the globe. For example, HGH groups reliant on marine protein require access to a coast, such as the Andamanese from the Andaman Islands in the Bay of Bengal (El-Zaatari, 2010; Kurki et al., 2010) or the Jōmon of precontact Japan (Turner II, 1979; Temple, 2010; Hoover & Hudson, 2016). The type of marine protein differs as well, for example, colder climates with fewer plant foods warrant an increased requirement for more accessible protein (Pontzer & Wood, 2021), advanced fishing technology encourages access to sea mammals (whales and seals), resulting in diets with high fat and protein and fewer carbohydrates, as seen in HGH groups along Alaska's coasts (Mayhall, 1970; Costa, 1980; El-Zaatari, 2010). In comparison, groups inhabiting warmer environments have more biodiversity and bountiful plant foods. Access to the coast and little fishing technology will encourage less energy expenditure by gathering carbohydrates in the form of sub-surface tubers or corms, or shellfish along the coast, as seen in southern Africa (Sealy, 1984; Pfeiffer et al., 2020).

Kelly (2013) published an extensive review of dietary component estimates for 125 global HGH groups, revealing the variability between HGH diets and their systematic relation to an environment when categorised as diets predominating hunting, gathering or fishing. The author indicated two caveats: ethnographic accounts encapsulated a large portion of the data, and the gathering variable grouped gathering of marine protein (e.g., molluscs), small mammals, and plant foods. Notably, some foragers did not exclusively exploit plant foods on expeditions but also small ground game (Lew-Levy et al., 2020) which justifies grouping a gathering variable. Kelly (2013) presented percent ratios of food component consumption with wide ranges; for example, there was an 80-90% reliance on hunting, predominantly in North American groups such as the Nunamiut, Sarsi, Blackfoot (Siksika), Crow (Apsáalooke), and Kiowa. There was a 76-85% reliance on gathering in southern African groups, ≠Kade G/wi, Ju/'hoansi (Dobe); G/wi; Chenchu of India; and Nukak of Colombia. Lastly, they reported a 70-80% reliance on fishing in the Angmagssalik of Greenland; and Sivokakhmeit and Alse of North America. Overall, the author interpreted that HGH groups tend to select foods through a cost-benefit trade-off, and choices are multifactorial relative to risk, energy expenditure, and resource availability.

In these sections, I reviewed HGH research and highlighted the different lifestyles and dietary structures related to the environment in which groups inhabited. The subsequent sections include limitations and benefits of including multiple lines of evidence for HGH research and developing intellectual frameworks for sAHGH research.

2.4 Hunter-gatherer and -herder research limitations

As Kelly (2013) discussed, limitations exist by including multiple research avenues that employ varying objectives and methodologies, yet most HGH studies continue to utilise a combination of archaeological, ethnographic, and historical sources to draw inferences. While there are limitations to ethnographic and historical studies, particularly with explanation bias, historical research has not been meaningless. For example, 20th century HGH research relied heavily on the 'hunting' component of precontact economies (Gallois & Henry, 2021), and efforts in assessing and discussing the prevalence of foraged foods and some groups' reliance on carbohydrates were largely due to the ethnographic work by Richard Lee on Kalahari hunter-gatherers (Lee, 1979; Kelly, 2013; Pontzer & Wood, 2021). Lee discussed the multidimensional nature of HGH societies, argued and provided evidence that plant foods composed most of the caloric intake for Kalahari Ju/'hoansi hunter-gatherers, and reported these results at the *Man the Hunter* symposium in 1968 (Lee & DeVore, 1968). In the realm of archaeological interpretation, their ethnographic contributions transformed perspectives on HGH diets. Moreover, additional contributions from ethnographic and historical accounts on the herding component to hunting and gathering lifeways also brought forth new perspectives, where in sAHGH communities, there was little archaeological and ethnographic evidence for slaughtering the herd (Sealy, 2010). Ethnographic observations affirmed that livestock was used mainly for milk, butter, and, eventually, trade (Sealy, 2010; Ginter, 2011).

Notably, limitations of ethnohistoric and ethnographic accounts against the archaeological record have been a key issue in contemporary research (Felt, 2020). Littleton (2018) collected dental data from Australian Aboriginal hunter-gatherers, namely dental wear, caries, pulp exposure, periapical voids, calculus, periodontal disease, and AMTL, and directly assessed their results with dental conditions reported in historical work to determine the accuracy. The author found a positive, general correspondence between their results and historic accounts in the same population, albeit the bioarchaeological assessment contributed to more detailed information. Attentive inclusion of multiple lines of evidence, such as ethnohistoric work alongside bioarchaeological data, has continued to enhance interpretations on the past (Buikstra & Beck, 2016), to provide the reader the ability to recognise any accuracies and inaccuracies in particular pioneering research. Furthermore, studies such as Kelly (2013), Littleton (2018), and for southern African remains, Morris (1992a) have also demonstrated that including earlier work may expand a dataset, resulting in improved statistical power or more robust observations. Consequently, interdisciplinary data remains critical to HGH inferences, and HGH diet variability has become an integral part of contemporary research on HGH communities. Acknowledging these aspects has been the crux of growing research in bioarchaeological subdisciplines for HGH, including dental anthropology, a subfield that relies on multiple avenues of research to draw inferences about the direct interactions between individuals, their diet, and behaviour.

2.4.1 Limitations in southern African research approaches

Philosophical paradigms in sAHGH research, in line with global transitions of new intellectual movements, have evolved to encompass a more social approach utilising multiple lines of evidence to reconstruct the past due to the genomic continuity of the sAHGH population, highlighting similarities and differences of social dynamics between contact periods (Mazel, 1989; Hall, 1990; Morris, 1992a; Wadley, 1997; Humphreys, 2007; Forssman et al., 2010; Lombard et al., 2012; Pfeiffer et al., 2014; Pargeter et al., 2016; Forssman, 2019). Southern African research frameworks have been a subject of academic conversation in response to the evolving discipline, aligning with regional socio-political dynamics while acknowledging biased approaches (Forssman, 2019).

Since descendants of the contemporary indigenous populations of southern Africa, the ‘San’, are one of the best-documented ethnographic hunter-gatherer groups, and consequently, sAHGH research has heavily implemented ethnographic studies (Pargeter et al., 2016). There is, however, a limitation as southern African ethnography has focused primarily on Kalahari groups (Forssman, 2019), exclusively representing the arid and semi-arid interior regions of southern Africa (Pargeter et al., 2016). Regardless, ethnographic research has been and continues to be a tool to help draw conclusions and connect aspects of evidence with the archaeological record (Pearce, 2012). These records are instrumental in the case of this thesis, where aspects unique to a southern African environment are required, such as additional dietary possibilities or tool use behaviours. These records are further valuable as data on the southern African interior has been limited (Lander & Russell, 2018), and southern African organic material are particularly poorly preserved and making inferences on the carbohydrate components of a diet is difficult (Sealy, 1984). Ethnographic information can elucidate dietary possibilities across the landscape (De Vynck, Van Wyk & Cowling, 2016; Botha et al., 2022). Therefore, these lines of evidence are not to be disregarded, leastwise the limitations acknowledged to explain how various research approaches apply to this study.

Ethnographic and historic research should not be intended as an analogue, and the inclusion of certain lines of research does not determine inferences made but act as additional possibilities knowing human behaviour is complex. As Humphreys (2007: 101) cites Deacon (1992) on archaeological interpretation: “reality may be more complex than we imagined.” This thesis hopes to consider all forms of reality as we know it and what we know is relative to published research to date as it pertains to a certain lifeway (HGH) as it is possible in a particular environment (southern Africa). As previously discussed, multiple lines of evidence can contribute to more robust observations when incorporated cautiously. Additionally, ethnographic research provides insight into some behavioural aspects relative to direct interaction with a particular region, such as in the context of southern African ethnography, the Kalahari interior. Where bioarchaeological data speaks directly to the biological manifestation of an individual’s interaction with their environment, multiple lines of evidence collectively help provide evidence for relations between potential behaviour and the bioarchaeological data (Pearce, 2012).

Forssman (2019) stated that research into precontact southern Africa might empower and represent descendant communities by encouraging an active, open relationship with their heritage. Basing current understandings on colonialist thinking without valuing renewed research was an issue as early perceptions of sAHGH during contact periods contributed to notoriously negative behaviours of colonialist settlers (Adhikari, 2010; Warren, 2021). Active research into sAHGH communities has since demonstrated diverse and rich social, cultural, and material cultures from various perspectives (e.g., technological industries, biological) (Forssman, 2019). Moreover, in recent decades, precontact cultures have increasingly been discussed as fluid and ever-changing over time (Pargeter et al., 2016).

It is critical to stress that sAHGH skeletal remains have been long subjected to assemblage housing at non-African repositories and museums, repatriation issues and unethical scientific practices (Mitchell, 1998; Botha & Steyn, 2013; Steyn et al., 2013; Gibbon & Morris, 2021; Walters & Jansen, 2022), atop a horrifying history during the colonisation of the nation (Adhikari, 2010). Although repositories and museums exist to provide opportunities for research and education, the complex history of southern Africa and how these remains ended up in foreign collections or the hands of unethical curators should not be ignored but discussed and highlighted in the literature, as these individuals are the foundations of this nation. Therefore, disseminating the findings from this study should be a local and global effort to help scientists and the common public understand the dynamics of these ancient societies through a biocultural approach. By assessing this population on a large and individualised level, this research attempts to demonstrate that these individuals were as unique from each other in the ancient past, as we are today.

This section highlighted the broader limitations and concerns in sAHGH research amidst recent conversations concerning sAHGH pasts. As Warren (2021) proposed, there is no unilinear method to studying HGH communities, and although applying global contexts of similar lifeways is relevant to understand the differences in behaviour, HGH communities require an understanding within their local context to shift the perspective of HGH generalisation (Forssman, 2019), and capture the unique lifeways of sAHGH individuals. Taking this into consideration, the following section is an appraisal of sAHGH literature to hone a thorough understanding of the local context of the southern African Holocene.

2.5 Southern African hunter-gatherers and -herders

sAHGH are recognised as genetically distinct within a sub-Saharan context with low levels of gene flow from other African populations, positioning them to have a unique and deeply-rooted lineage lacking genetic admixture despite developments in socio-economic practices (Pickrell et al., 2012; Schlebusch & Soodyall, 2012; Barbieri et al., 2016). Consequently, sAHGH are a focus of several studies investigating modern human origins (Sealy & van der Merwe, 1986; Pfeiffer & Harrington, 2011; Orton et al., 2013; Irish et al., 2014; Pfeiffer et al., 2020). The isolated nature of sAHGH populations over millennia is partly due to the diverse geography of southern Africa (Rutherford, Mucina & Powrie, 2006) and an expansive arid interior that was more challenging to inhabit (Lewis, 2008). Such a localised population makes the sAHGH lifeway distinct to the region, and observing sAHGH behaviour is possible in direct relation to the environment with no admixture from other populations over millennia. To provide a thorough understanding of sAHGH in a local context, I will review the precontact inhabitants of southern Africa, their lifestyles, diet, and behaviour throughout the Holocene as reported by past archaeological, bioarchaeological, and ethnographic research.

2.5.1 The archaeological record during the Holocene

The southern African Holocene (≤11,700 years) is often discussed with the introduction of herding from 2000 BP as a pivotal point, resulting in temporal demarcations of pre and post-2000 BP. Some studies have further assigned three additional temporal divisions for this epoch: the earlier Holocene (11,700 - 4000 BP), middle Holocene (4000 - 2000 BP) and later Holocene (2000 - present) (Stynder, 2006). These temporal divisions were archaeologically determined as introduced through new tool industries and changes in subsistence economies. Before 2000 BP, the archaeological record suggests hunting and gathering as the exclusive subsistence economy (Mitchell, 2002). From about 12,000 BP and between the earlier and middle Holocene, there was a transition into microlithic tools predominating the region, known as the Robberg Industry, to the Oakhurst Complex, a macrolithic industry (Lombard et al., 2012). The macrolith-dominant Wilton Complex was introduced from 8000 BP (Lombard et al., 2012), followed by an increase in population size (Pfeiffer & Harrington, 2011). This industry change resulted in changing site stratification, slight dietary adaptions in resource exploitation, and widespread material culture (Mazel, 1989; Hall, 1990; Binneman, 1996; Jerardino, 1996; Deacon & Deacon, 1999; d'Errico et al., 2012). A reduction in sAHGH body size occurred during the middle Holocene, from about 4000 BP (Sealy & Pfeiffer, 2000; Pfeiffer & Sealy, 2006; Pfeiffer & Harrington, 2011). Following the introduction of herding from around 2000 BP, sAHGH body size recovered in line with earlier Holocene (pre-4000 BP) measurements, and research has shown that this was due to an adaptation to the environment (Pfeiffer & Sealy, 2006) or biome (Churchill & Morris, 1998), or sudden dietary adequacy (Pfeiffer et al., 2019), currently correlated to the introduction of a herding component and increased delayed-return strategies (Sealy, 2006).

Some studies have focused on site-specific contexts because particular regions are notable in the literature due to selective settlement patterns (Sealy, 2006) or fluctuating population densities (Deacon, 1974; Sealy & van der Merwe, 1988; Morris, 2002), either during specific seasons in the year or during periods of climate change (Lander & Russell, 2018). However, some sites preserved occupation layers better than others in the archaeological record and provided more evidence for transition periods. The stratigraphy of the coastal site of Elands Bay, for example, provides a sequence of events over a large expanse of time. A prolonged arid period and higher sea levels submerged accessible shellfish between 7800 and 4000 years ago at the site and dropped again by 3000 BP, resulting in fluctuating population density between the earlier and middle Holocene (Sealy & van der Merwe, 1988; Jerardino, 2003; Orton, 2020). From the middle Holocene, occupation resumed at many cave sites along the coast, as evidenced by the increased frequency of lithic assemblages. Archaeological remains became scarce after 3000 BP, and the discovery of 'open shell middens' adjacent to intertidal platforms replaced previous material (Pfeiffer, 2007).

The presence of plant food debris, stone tools, and small animal bones increased in the region around 2000 BP, as pastoralism became more prevalent in coastal and interior regions (Sadr, 2008a; Sealy, 2010; Lander & Russell, 2018). The size of coastal shell middens also diminished, but their number increased, along with the number of terrestrial debris (Sealy & van der Merwe, 1988; Stock & Pfeiffer, 2004). Generally, skeletal recovery and the occupation of such areas determine the presence of individuals across sites. Coastal regions were ideal for inhabiting due to the productivity of the Atlantic and Indian oceans (Sealy, 1984; Irish et al., 2014), yet mobility across the landscape has been noted (Jerardino, 2020).

Southern African topography

Both physiographic and biotic (Rutherford, Mucina & Powrie, 2006) zones have been used in southern Africa to classify regional boundaries. Vegetation structures and climates governed the movement and subsistence of precontact humans and animals and determined classification systems between biogeographical areas (Botha, Siebert & Berg, 2016). Classifying such a large and variable land expanse was proven complex, and demarcation becomes arbitrary with highly mobile humans and animals (Morris, 1992b). Further, demarcations between regions are not static models, in that changing climate and landscapes with passing time present difficulty against specific boundaries (Deacon, 1974; Morris, 2002), although southern African climates over the last 5000 years have been similar to today (Churchill & Morris, 1998).

Due to these complexities and to encourage systematic analyses, this study uses simplified geographical boundaries of coastal and inland that past studies have already effectively implemented (Pfeiffer & Sealy, 2006; Pfeiffer et al., 2019; Gibbon & Davies, 2020). Southern Africa possesses a notable geographic feature within the Cape provinces, the Cape Fold Belt, which forms a partial barrier between coastal regions and in-land (Pfeiffer et al., 2019). As a result, coastal regions reach from the coast of the western and southern Cape to the mountains of the Cape Fold Belt, ending around Clanwilliam in the north and around Gqeberha in the east (Figure 2.2) (Truswell, 1977; Klein, 1984; McCarthy & Rubidge, 2005). Coastal contexts not within the Cape are other coastal regions within 20 km of the coastline. In-land regions are all interior areas of the Cape Fold Belt (Pfeiffer & Sealy, 2006; Gibbon & Davies, 2020).

Figure 2.2: Satellite map of South Africa from Google (2022), adapted and edited by the author. All text and solid line borders marked on the map are modern territories. 'X' symbols indicate the extent of Cape Fold Belt coastal contexts, and the dotted line demonstrates the general location of the Cape Fold Belt. The map is scaled for 1:200.

Rainfall depends on the biome and season along the coast. For example, Forest biomes experience the most rainfall year-round, whereas the Fynbos biome experiences winter rainfall

(May to August). Consequently, coastal regions can have mean annual rainfall between 400 to 1000 mm (Rutherford, Mucina & Powrie, 2006; South African Weather Service, 2022). Topography varies greatly; as in the Cape alone, there are Cape Fold mountains, coastal dunes and Afromontane forest, and the east is predominantly grassland (Rutherford, Mucina & Powrie, 2006). The region between the coast and the Cape Fold Belt is the Greater Cape-Floristic Region (SANBI, n.d.). This subdivision of the South African floristic kingdom covers an area of 80,000 km2 and is home to unique floristic diversity, as in an abundance of fynbos, including plant species such as Restionaceae, Compositae, Ericaceae, and Kranz (Klein, 1984; Meadows & Sugden, 1993; Churchill & Morris, 1998).

Inland regions include the grassland, desert, savanna, and karoo biomes, which have a continental climate but significant temperature variation. Summer temperatures surpass 30°C, but winter temperatures can drop below zero from strong and cold Atlantic winds (Rutherford, Mucina & Powrie, 2006). Precipitation also varies; the general rainy season of the arid interior occurs between December and March, and the dry season is between April to November, although some biomes, such as the Succulent Karoo, exhibit winter rainfall. Mean annual precipitation can range between 168 to 661 mm (Rutherford, Mucina & Powrie, 2006). The topography of the interior past the Cape Fold Belt is relatively flat and dry, with occasional pans, seasonal streams, plateaus and dunes (Tanaka, 1980; Rutherford & Westfall, 1986; Rutherford, Mucina & Powrie, 2006). The interior possesses variability, as the areas around the Orange River, for example, demonstrate an unpredictable rain season encouraging shrub and grass growth (Morris, 1992b). Flora is otherwise limited compared to the coast, but vegetation has adapted to the harsh aridity in the forms of shrubs, grasses and trees (Tanaka, 1980).

Lifestyle, behaviour, and diet

sAHGH were the sole occupants until about 2000 BP with the migration of Iron Age agropastoralists (Morris, 2002), and historical records suggested sAHGH were small family-based bands comprising 10 to 30 people, rarely exceeding groups of 50 individuals (Adhikari, 2010). The introduction of sheep and cattle founded the hunting-herding economy, and although researchers contest theories of the precise origins and migration of pastoralism, the most common theory is that herding as a strategy was a gradually attained idea that migrated through two separate events along the Atlantic seaboard, and through the middle of southern Africa along the Limpopo River Basin (Sadr, 2015). A herding lifeway, however, did not largely affect hunting and gathering economies, and sAHGH continued to live active lifestyles, hunting and foraging while practising pastoralism (Sealy, 2010).

The lifestyles of sAHGH have been reconstructed through archaeological and bioarchaeological research and supported by ethnographic studies over the last few centuries. The sAHGH lifeway generally involved foraging regional vegetation and shellfish where there was a coastline, trapping and hunting small to large-sized animals, with some groups herding livestock from 2000 BP. The organic dietary record differs slightly between coastal and inland regions, and this record was compiled using faunal and vegetal remains (Sealy, 1984), isotopic signatures (Sealy & van der Merwe, 1988; Sealy, 2006; Pfeiffer et al., 2019), contemporary ecological research (Botha, Siebert & Berg, 2016; De Vynck, Van Wyk & Cowling, 2016; Botha et al., 2022), and ethnographic evidence (Lee, 1978, 1979; Tanaka, 1980; Silberbauer, 1981). Archaeological artefacts include lithics, ostrich eggshell water containers, ostrich eggshell beads, ochre, tortoiseshell bowls, and from post-2000 BP, fired pottery (Mitchell, 2002; Lander & Russell, 2018, 2020). Organic materials such as twine, leather and sinew contribute to the creation of clothing, bows and huts (Lander & Russell, 2020), and evidence of tools involve bows and arrows, digging sticks, bored stones, pestles and mortars, and grinding stones (Jerardino, 1996; Wadley, 1997; Lander & Russell, 2018).

Burial practices differ relative to the time and region (Morris, 1992b; Wadley, 1997; Pfeiffer et al., 2020). For instance, the west coast of the western Cape has a record of individual sAHGH interments occurring soon after death, with the body buried on the side with flexed legs, and grave goods were rare. This differs from historical observations in the northern parts of South Africa, where the body was adorned with beadwork and wrapped in a kaross (Pfeiffer et al., 2020). Pfeiffer and colleagues (2020) suggested that funerals were not always elaborate rituals. However, regional and temporal variation has been evident. The authors considered this aspect in instances where a selected locale included the deceased of various demographic characteristics (i.e., sex and age) over an extended time, thus representing several generations (Pfeiffer et al., 2020). Bioarchaeological and archaeological evidence demonstrates that sAHGH lifeways span a long time, and behavioural practices did not stagnate over the Holocene.

Archaeological subsistence strategies have been of interest since the 1930s (Deacon, 1984) due to the difficulty delineating subsistence transitions in sAHGH pasts. Herding was introduced around 2000 BP, however, its precise origin and migration into southern Africa remain contested (Deacon et al., 1978; Sadr, 1998, 2008a; Sealy, 2010; Ginter, 2011; Orton et al., 2013; Sadr, 2015; Lander & Russell, 2018). Research has reconstructed this transition using archaeological or isotopic evidence (Sadr, 2008b; Sealy, 2010; Lander & Russell, 2018). However, some studies considered past climatic and environmental changes to provide context for why domesticate bones and cremains (Bousman, 1998) and organic materials (Lander & Russell, 2020) appear in rock shelters in specific environmental conditions. Studies have used multidisciplinary approaches because transitions to new subsistence economies are seldom unilinear. Despite this, we generally understand the staple foods consumed by sAHGH throughout the Holocene.

The sAHGH diet was a mixed-economy diet, although there was roughly an 80% reliance on plants (El-Zaatari, 2010) in the form of geophytes, gums, seeds, nuts, fruits, and berries, including bulbs, corms, rhizomes and tubers such as Iridaceae (Sealy, 1984; Churchill & Morris, 1998; Pfeiffer, 2007; Ginter, 2011; Botha et al., 2022). Along the coast, marine proteins such as near-shore fisheries, molluscs (mussels, limpets), fish, and crayfish were an abundant and consistent resource, and occasional bird nesting areas, stranded whales, and seal rookeries (Sealy, 1984; Pfeiffer, 2007; De Vynck et al., 2016; Jerardino, 2020), provided reasonable amounts of calories in the form of protein and fat (De Vynck et al., 2016). The fat content, in particular, was in a greater proportion than what was available from the meat of small terrestrial animals (Pfeiffer et al., 2019). Due to this large yield of accessible marine resources and the nutritional advantages, the coast was an attractive environment to inhabit (Pfeiffer, 2007). Past studies demonstrating dietary variability in resource consumption within human remains uncovered from coastal sites indicate that the coastal diet was not uniform in space or time (Sealy et al., 1992; Sealy & Pfeiffer, 2000; Sealy, 2006, 2010; Pfeiffer et al., 2019). As lunar cycles and seasonally rough seas limit the intertidal zone (De Vynck et al., 2016), coastal foragers occasionally had to access food further inland (Pfeiffer et al., 2019). Sealy and Pfeiffer (2000) also suggested an overall reduced reliance on marine protein after 3500 BP, due to geographical differences that determined what resources were accessible between specific sites. Coastal terrestrial species diversity depended across the region and season. It was dominated by small to medium fauna, including angulate tortoises (*Chersina angulate*), rock hyrax (*Procavia capensis*), bushpig (*Phacochoerus*), common duiker (*Sylvicapra grimmia*), blue duiker (*Cephalophus monticola*), klipspringer (*Oreotragus oreotragus*), steenbok (*Raphicerus campestris*), and grysbok (*Raphicerus melanotis*). Of large mammals, Cape buffalo (*Syncerus caffer*), elephant (*Loxodonta Africana*), hippopotamus

(*Hippopotamus amphibius*), zebra (*Equus burchelli*), quagga (*Equus quagga*), eland (*Taurotragus oryx*), and hartebeest (*Alcelaphys buselaphus*) have been recovered in archaeological sites or recorded by historic travellers within open and grassy veld along the coast but are absent today due to limited grassland and urban development (Deacon, 1984; Sealy, 1984; Churchill & Morris, 1998; Jerardino, 2020).

Inland diets were similar, bar the consumption of marine protein. Inland plants included geophytes such as *Watsonia* and *Hypoxis* (Sealy, 1984; Churchill & Morris, 1998), ultimately sAHGH prioritised species with edible underground storage organs (Pargeter et al., 2018; Botha et al., 2022). Ethnographic and ecological studies have also reported the gathering and consumption of plants such as melons, gums, Mongongo nut, baobab fruit, beans such as the Kalahari white bauhinia (*Bauhinia petersiana*), and *Grewia* berries (Lee, 1979; Tanaka, 1980; Silberbauer, 1981; Botha et al., 2022). Honey also may have played a role, as referenced in numerous ethnographic accounts according to Russell and Lander (2015). The fauna of the landscape depended on seasonal movements and was limited to animals that had adapted to drier climates (Churchill & Morris, 1998). For example, larger grazing mammals such as eland (*Taurotragus oryx*), zebra (*Equus zebra*), Cape buffalo (*Syncerus caffer*), black rhino (*Diceros bicornis*), and elephant (*Loxodonta africana*), migrated through the Kalahari during the rainy season. Although the appearance of springbok (*Antidorcas marsupialis*), baboons (*Papio ursinus*), and galago (*Galagidae*), along with animals such as kudu (*Tragelaphus strepsiceros*), impala (*Aepyceros melampus*), jackals (*Lupulella mesomelas*), Cape hare (*Lepus capensis*), and Cape foxes (*Vulpes chama*) were smaller-sized protein staples (Tanaka, 1980; Churchill & Morris, 1998; Pargeter et al., 2018).

The starchy roots of underground plants would have been abundant and easy to collect (Pfeiffer et al., 2019; Botha et al., 2022), where geophytic corms and berries were foraged in the summer months (October to April) around the Cape Fold Mountain Belt, and in the winter months (May to September) along the coast (Sealy, 1984). sAHGH also stored plants in underground storage pits further inland (Deacon et al., 1978; Pargeter et al., 2018). Although there were likely other plant foods of importance, organic evidence of carbohydrate resources are limited due to the poor preservation of plant remains in the archaeological record. The frequency of plants such as corms preserved well because the subterranean parts of the plant, such as fibrous casings, were preserved better than other parts, such as in the leaves, stalk, flower, or fruit (Sealy, 1984). Shellfish and small animal proteins (e.g., hare, tortoises and hyrax) were dependable resources as they could be trapped and gathered rather than hunted, thus, requiring less energy to obtain (Sampson, 1974; Sealy, 1984). Tortoises could be collected in large numbers during the spring and summer, preferably in the coastal sandveld (Pfeiffer & Sealy, 2006), whereas hyraxes could be found in the mountains or on rocky outcrops throughout the year (Sealy, 1984).

'Herding', pastoralism of sheep and cattle, was introduced from outside the region; however, hunter-gathering and -herding co-existed as subsistence economies within sAHGH communities (Ginter, 2011). Agriculture was not practised in sAHGH communities until San and/or Khoe farm labourers became prevalent post-colonialism (Botha & Steyn, 2015, 2016). Concerning herders, historical records noted a reluctance to slaughter livestock where the animals were more often used as status symbols or traded, implying the continued necessity for hunting and gathering skills throughout the Holocene. Milk was the most valuable asset for possessing livestock, either for nourishment or butter (Deacon, 1984; Russell & Lander, 2015).

Herding as a dietary strategy has been used in tandem with 'hunting-gathering' where relevant, as in many cases, there was an incorporation of herding livestock, goat (*Capra*), sheep (*Ovis*), or cattle (*Bos taurus*), into a pre-existing lifeway that continued to rely on hunting and gathering (Sadr, 2013). Where some research has interpreted herding as a unilinear process of the exploitation of resources, leading to agriculturalism (i.e., animal management and crops) (Van Neer et al., 2013; Rosen, 2019), the synergetic strategy of hunting, gathering, and herding is a unique and multidimensional dynamic, particularly in southern Africa (Deacon et al., 1978; Sealy, 2010; Sadr, 2013, 2015). Moreover, identifying the differences between subsistence strategies such as hunting, gathering, and herding has been difficult using archaeological evidence, as 'herding' is considered a transitional society where its regional sequences of cultural evolutions of origins cannot be identified. Therefore, research would base this on criteria that cannot be conclusively distinguished and do not speak for the broad interaction of humans and the environment (Kusimba, 2005).

This section provided a broad review of southern African archaeological findings and the general timeline, lifestyles, behaviours, and dietary choices for sAHGH based on interdisciplinary research conducted to date. Markers observed in an individual's teeth rely on these factors; thus, understanding a group's lifeway is integral to understanding oral conditions. The subsequent section discusses general observations and expectations for HGH dentition based on global literature, followed by a localised review of conducted sAHGH dental studies.

2.6 Hunter-gatherer and -herder dentition

In dental anthropological studies, dental wear and pathology identify population-wide health or transitions into new lifeways or subsistence strategies. Despite dietary variation across ecologies (Kelly, 2013), HGH teeth are generally affected by similar wear and pathological processes because simplified food processing strategies led to tougher and more fibrous food consistencies (Smith, 1984), and a lack of refined carbohydrate consumption reduced cariogenesis and plaque growth (Temple, 2016). HGH dentition typically exhibits heavy, flat dental wear and good oral health (i.e., fewer occurrences of dental diseases) (Smith, 1984; Lieverse et al., 2007; Fiorenza, Benazzi & Kullmer, 2011; Littleton et al., 2013; Humphrey et al., 2014; Górka, Romero & Pérez-Pérez, 2015; Littleton, 2017, 2018), whereas contemporary populations show opposite patterns, such as in agriculturists (Turner II, 1979; Smith, 1984; Eshed, Gopher & Hershkovitz, 2006; Deter, 2009; Górka, Romero & Pérez-Pérez, 2015), since refining foods reduces the rate of dental wear while simultaneously increasing cariogenic bacteria (Towle et al., 2021). Although, dental pathology and its presence is circumstantial, and as Marklein and colleagues (2019) argue, surrounding environmental and biological nuances must be considered when making inferences on HGH populations from dental conditions. This is particularly relevant when considering the multifactorial nature of dental conditions, especially considering dental wear contributes greatly to pathology susceptibility (Kaidonis, 2008).

Human dentition has evolved to accommodate heavy dental wear since our hominin ancestors. Kaifu and colleagues (2003) extensively discussed the evolutionary development of human dentition through ‘heavy-wear’ precontact populations. Their results suggested a disparity between HGH dentition and contemporary societies that use specialised food processing and domesticated crops, which some contemporary dental issues may reflect. For example, they surmised the dentition adapted compensatory mechanisms for heavy interproximal and occlusal wear, resulting in issues such as gradual displacement of teeth in the bone (mesial drift), continuous eruption throughout life, and labial inclining of the front teeth (lingual tipping) (Kaifu et al., 2003). Their study required further investigation, and Benazzi and colleagues (2013) eventually also assessed the evolutionary paradox of potential dental wear adaptation and its effect on consequential oral pathology using finite element analysis (FEA). The authors discovered that rapid wearing in precontact people balanced stress distribution across the surface in a HGH individual's lifespan better than in contemporary non-worn or moderately worn teeth. As such, contemporary dental problems may occur from imbalanced tensile stresses in localised regions on the tooth, and heavy, flat wear is suggested to be an evolutionary advantage and adaptation in HGH teeth, reducing bacterial growth between occlusal cusps (Benazzi et al., 2013). The authors concluded that other factors still played a role in the physiology of precontact dentition, where examples can include: an individual's ratio of fibrous carbohydrates to meat or fish protein (Kelly, 2013), food processing such as the consumption of dried *versus* cooked meat (El-Zaatari, 2010), or culture-specific activities (Romero et al., 2019) including parafunctional habits (Minozzi et al., 2003), all continue to affect the rate of wear and pathological expression between HGH individuals.

Researchers continue to discuss whether heavy wear in precontact HGH teeth explains the low expression of oral pathology (Larsen, 2015). However, authors such as Kaifu and colleagues (2003) and Meiklejohn and colleagues (1992) indicated that excessive wear does not ensure pathological resistance, and oral pathology and wear remain greatly multifactorial (Crittenden et al., 2017). Researchers have manoeuvred this conversation by examining local HGH populations that resided in similar regions with no inter-group interactions. Interestingly, there has been unexpected variation in dental wear and pathological expression between groups that subsist from similar ecologies. For example, Costa (1980) reported caries and abscess prevalence between three precontact Inuit groups from Alaska, where the Ipiutak had notably higher caries rates than the other local groups. The Ipiutak had caries rates within the ranges of modern people whose diets included high quantities of starches and sugars, although there was no evidence that they ingested excess sugars. As a result, the differences in caries rates between the three groups were likely due to slight differences between the proportions of protein, fats, and carbohydrates within a single dietary structure. Littleton and colleagues (2013) also reported variability in wear patterns for Australian Aboriginal teeth, as different tooth types were significantly affected for males from five different groups compared to females and mixed-sex groups from other Australian HGH groups. The variation was due to slight differences in non-masticatory use of the teeth between sexes and reliance on bulrush (*Typha*) for nourishment in particular individuals. In HGH groups of Siberia's Cis-Baikal region, Lieverse and colleagues (2007) suggested a potential positive correlation between caries and attrition; however, other oral pathologies such as AMTL and periodontitis, conditions commonly associated with the presence of caries (Hillson, 2001), varied considerably between groups. One documented example at the site of Shamanka II had substantial frequencies of periodontitis and AMTL, and the authors suggested its aetiology was more complex than dental wear, as wear was also lower in these regions (Lieverse et al., 2007). Consequently, variation may have reflected cultural, geographical or environmental contexts.

Cultural contexts affecting different individuals of the same group, tribe, or clan have also been notable in HGH literature, most commonly reflected by intra-group sexual dimorphism as evidenced in several global HGH populations (Walker & Hewlett, 1990; Keenleyside, 1998; Lieverse et al., 2007; Littleton et al., 2013; Luna & Aranda, 2014; Littleton, 2018). Luna and Aranda (2014) reported sexual dimorphism in caries prevalence on HGH from central Argentina, of which females demonstrated significantly more oral pathology. These results elucidated cultural differences in food consumption, oral hygiene practice, and food processing between sexes of the same group. In summation, the authors were able to observe and justify heterogeneous lifestyles in the same ecological region. Attention must be paid, not only to global HGH group comparisons, but to the possible variation in both intra- and inter-group examples. Littleton (2018) assessed Australian Aboriginal HGH from Roonka and reported sexual dimorphism in the pattern of oral pathology and degree of wear among individuals from the same location, emphasising the importance of taking intra-group dietary and regional differences into account in future global HGH research.

Many HGH studies have also found activity-related dental patterns such as greater wear quantity on the anterior teeth, suggesting a regular use of the teeth as a third hand corresponding with different occupational strategies (Brown & Molnar, 1990; Milner & Larsen, 1991; Deter, 2009; Littleton et al., 2013; Littleton, 2017). Furthermore, intentional behaviours related to oral hygiene within a single group also affect an oral cavity and have been notable in HGH literature. Examples include manual intervention for dental cleaning (Oxilia et al., 2015, 2017) or inflammation alleviation (Hinton, 1982; Brown & Molnar, 1990; Turner II & Cacciatore, 1998; Ungar et al., 2001; Bonfiglioli et al., 2004). One of the oldest occurrences (*ca*. 14,160-13,820 BP) of manual intervention in a precontact individual from Italy, reported by Oxilia and colleagues (2015), identified chipping and striations that supported the assumption that they attempted to remove a carious lesion intentionally. Otherwise, studies provide evidence of therapeutic dental treatment through markers from tools resembling dental picks (i.e., toothpicks) to alleviate inflammation (Hinton, 1982; Brown & Molnar, 1990; Ungar et al., 2001; Bonfiglioli et al., 2004).

The degree of influence aspects such as genetics play a role in precontact groups, or early hominins remains unclear (Towle et al., 2021); however, external influences, as demonstrated in this section, such as diet and behaviour, have been consistently integrated into the assessment of precontact remains. However, using dental wear and oral pathology to identify population-wide health or transitions into adaptive strategies has been successful in dental anthropology studies on HGH teeth. Through dental anthropology, global studies have managed to suggest hypotheses and research questions that distinguished nuances between inter and intra-group dental characteristics, for example, Littleton (2017) acknowledged hypotheses for age-related roles in HGH populations through dental wear age-grading. Additionally, Deter (2009) confirmed dental wear occurs alongside dental eruption, but is greatly influenced by behaviour and diet as demonstrated by HGH dentitions compared to agriculturalists.

The discussion in this section was by no means an exhaustive assessment of all potentially relevant global HGH groups in the literature; as demonstrated, HGH research spans wide chronologies and space. The purpose of this section was to present the similarities and nuances in global HGH dentition as exhibited through various past HGH dental anthropological studies. This section further provided an overview of the various global contexts of HGH dentition and how variation between global HGH societies, groups of the same ecology, and individuals of the same group can present notable observations in the overall state of dentition. Due to the focus of this thesis on sAHGH individuals, the local context is integral to dental observations, as was demonstrated in this section. A review of conducted sAHGH dental studies follows in the subsequent section.

2.6.1 Southern African hunter-gatherer and herder dental studies

The first dental anthropological studies on sAHGH teeth initiated in conjunction with cranial investigations of sAHGH remains appeared in the early 1900s (Broom, 1923, 1941; Drennan, 1929). These studies focused on morphological and metric traits, which other studies later concentrated on (Van Reenen, 1964, 1966; Irish, 1993; Black, 2014; Irish et al., 2014). In line with the small body size of sAHGH (Pfeiffer & Sealy, 2006), their teeth are also morphologically microdont, which means they are metrically smaller compared to other human groups, but relative to body size, they are standard (Black, 2014). The palate is more shallow (Irish, 1993), with a smaller mandible, and these orofacial morphological characteristics remained uniform throughout the Holocene (Ginter, 2011), corresponding with sAHGH cranial size (Irish, 1993).

Apart from cranial and dental morphology, Drennan (1929) also included occasional observations of aspects such as dental wear. Drennan (1929) reported ‘moderate’ wear on sAHGH dentition, using Broca’s (1879) four-stage index, but did not address the direction of wear using a specific method, only reporting general slope directions (downward or inward). Further caries assessments led the author to conclude that rapid occlusal wear, influenced by a tough diet and small tooth size, caused lower caries prevalence on the teeth. This research initiated sAHGH dental anthropology, and over the next century, several authors incorporated dental wear quantity and oral health (Van Reenen, 1964, 1992; Morris, Thackeray & Thackeray, 1987; Sealy & van der Merwe, 1988; Sealy et al., 1992; Pfeiffer, 2007; Botha & Steyn, 2015; Orton et al., 2015; Gibbon & Davies, 2020; Pfeiffer et al., 2020). A general understanding of sAHGH dental wear appears to follow global HGH patterns, where sAHGH exhibit moderate to heavy, flat wear (Morris, 1992a; Pfeiffer, 2007; Orton et al., 2015), and wear on the anterior teeth may be more pronounced (Botha & Steyn, 2015; Gibbon & Davies, 2020), supporting the notion of using the teeth as tools to process hides or strip plants (Botha & Steyn, 2015). Odontological research has shown that the microdont nature of sAHGH teeth may contribute to rapid tooth wear, as smaller teeth may expose the pulp chamber more readily (Van Reenen, 1964).

Typically, oral pathologies are ‘minimal’ (Morris, 1992a; Van Reenen, 1992), with low levels of AMTL (Morris, 1992a) and caries rates that correspond with global HGH populations (Sealy et al., 1992) of frequencies ranging between 1 to 5% of carious teeth (Towle et al., 2021). Although Towle and colleagues (2021) reported this range from nine South African fossil hominins, the figures were in line with suggestions by Turner II (1979), who compiled data on 12 precontact populations, which sAHGH literature references (Sealy et al., 1992). Towle and colleagues (2021) suggested that the data using South African hominins also reflected sAHGH lifeways, as they relied on the same resources and environment. Morris (1992a) also compiled incidence rates of dental caries across numerous southern African populations, both archaeological and contemporary, based on their and past authors’ data. Of the sAHGH groups mentioned, the ranges to carious teeth were between 0.5 and 5.5, utilising data from their study, Drennan (1929), Van Reenen (1964), and Turner II (1979). Similarly, AMTL incidence rates, as reported for contemporary HGH by Morris (1992a), the Kakamas, was 4.1% of teeth lost antemortem.

Other general sAHGH observations highlight lower incidence rates for infectious lesions (Pfeiffer et al., 2019; Gibbon & Davies, 2020) and few (Pfeiffer et al., 2019; Gibbon &

Davies, 2020) to moderate (Botha & Steyn, 2016) amounts of hypoplastic defects. Where hypoplasia is concerned, Botha and Steyn (2016) reported EH to occur in 30.9% (17/55) of individuals, although the study included late 19th/early 20th century San and/or Khoe remains, and they indicated few individuals lived independently from the Cape colony even with seasonal migration inland to conduct traditional HGH strategies. Therefore, their nutrition reflected European colonialist influence. Minimal dental trauma incidence, where any microchipping was related to dietary behaviours (Van Reenen, 1992), with interpersonal trauma manifesting more frequently on the crania (Gibbon & Davies, 2020; Morris, 2020) rather than on anterior teeth. Calculus presence greatly varies (Pfeiffer et al., 2020), although its presence in archaeological remains is widely affected by postmortem processes and excessive handling (Lieverse et al., 2007) which justifies the lack of its inclusion in most studies. Concerning malocclusion, dental crowding is rare in sAHGH dentitions, occurring in only 10% (Black, 2014), likely reducing the risks associated with additional pathological factors associated with extensive crowding, such as increased trauma (Craddock & Youngson, 2004). While these findings are characteristic of the sAHGH dentition, some researchers have reported on specific aspects of the teeth, where demographic factors have either indirectly or directly influenced the results. Hypotheses have included questions related to the dental status of sAHGH, such as whether different local sAHGH exploited different resources as reflected by dental wear, pathology, and isotope analyses (Sealy et al., 1992), or whether the transitionary phase from a traditional sAHGH lifestyle into other societies was reflected by dental wear and paleopathological changes (Botha & Steyn, 2015). These and additional findings as reported by sAHGH dental studies are further elaborated upon in the following subsections based on variables involved in this thesis: sex, age, space, and time. Any remaining literature gaps are addressed at the end of this section.

Impact of sex

Black (2014) reported that metric odontological features showed low sexual dimorphism, confirming Van Reenen's (1970) observations that tooth size and dental traits were generally consistent between sexes. Consequently, one can assume that sexual dimorphism in sAHGH dentition correlates with gender-based behaviour through mechanical or physiological processes, such as dental wear and pathology. Some studies report on sexual dimorphism in pathology presence or dental wear quantity (Sealy & van der Merwe, 1988; Morris, 1992a; Van Reenen, 1992; Botha & Steyn, 2015; Gibbon & Davies, 2020), where a few authors found little to no sex-differences (Sealy et al., 1992; Gibbon & Davies, 2020). However, a lack of sexual dimorphism is noteworthy, as reported by Gibbon and Davies (2020), as it implies women recovered effectively from female-specific biologically stressful life events, namely childbirth, demonstrated by similarities in stress markers between sexes, including EH. This illustrated female sAHGH biological resilience. One study by Sealy and van der Merwe (1988) reported that females had greater dental wear quantity, and 2.2% (10/449 teeth) of carious teeth *versus* 1.1% (6/509 teeth) in males, in a small, coastal sAHGH cohort. The authors attributed this to a female role in foraging expeditions and, as a result, greater interactions with carbohydrates. The conclusions drawn reflected a women's role of 'gathering' based on ethnographic accounts. Additionally, the male δ13C isotope measurements indicated that females consumed more terrestrial diets than males before the later Holocene (Sealy & van der Merwe, 1988). Van Reenen (1966) also found caries incidence to be higher for females at 14.1% (27/37), compared to males at 4.7% (10/37), also correlating this find to foraging expeditions and females sampling the plant foods as they were collected.

Van Reenen (1992) found conflicting dental wear results between sexes in living 'San' individuals inhabiting the Kalahari Desert, Botswana, studied in 1958, 1959, and 1964 (n = 215 males; n = 191 females), and archaeological 'San' crania housed at southern African museums (n = 140 males; n = 102 females) using an eight-stage scoring system as published by Davies and Pedersen (1955). They reported in the crania sample that tooth wear was greater in males than females, and overall, anterior teeth tended to wear ahead of the posterior teeth, suggesting that males used these teeth more, which was assumed to be due to daily tasks rather than simply mastication. On the converse, Van Reenen (1992) found wear to be greater in females in the living HGH group, mainly in the mandibular first molars; although the authors did not elaborate further on this observation, this living 'San' group reportedly maintained a complete hunter-gatherer lifestyle.

Botha and Steyn (2015) discovered that greater wear occurred on female central incisors in contact period San and/or Khoe remains from the late 19^{th} and early 20^{th} centuries, suggestive of using the teeth as tools for tasks that involved the front teeth more frequently. Further, the authors also reported different patterns of AMTL between males and females, where males showed a high incidence of incisor and molar loss and females of third molars. They suggested male patterns of AMTL may relate to trauma or interpersonal violence, and female patterns represented tooth loss from caries, as molars are highly affected by bacterial growth. The chronology of their sample is worth noting, as the authors indicated that the individuals likely had a mixed diet of hunting meat and collecting plants from the wild and agricultural foods from farms, therefore, they ate refined carbohydrates (Botha & Steyn, 2015). Conversely, Morris (1992a) reported that the general expression of AMTL was low in either sex on the 'Kakamas' group, contact period south African individuals who maintained a HGH lifestyle. The average number of teeth lost per mouth in males and females was equal in young (0.4 average teeth lost) and almost equal in old-age (male: 5.1, female: 6 average teeth lost) categories. These studies demonstrate the variation observed between studies assessing site-specific remains from narrow time periods.

Impact of age

As older individuals tend to exhibit heavier attrition and more dental disease (Lukacs, 2007), there has been a strong correlation between AMTL presence and age when including age-at-death variables (Morris, Thackeray & Thackeray, 1987; Pfeiffer et al., 2019, 2020; Gibbon & Davies, 2020). This was further complicated when older adults were included in bioarchaeological studies, as this positive correlation affected additional observations; for example, Sealy and colleagues (1992) noted this limitation in an elderly sAHGH individual with only seven remaining teeth. Younger adults demonstrate fewer caries, comparing 3.1% (4/37) carious young adult individuals to 28% (23/37) middle-aged and 11.3% (6/37) old-aged individuals (Van Reenen, 1966). The author correlated these caries rates to be related to rapid wear.

On the other hand, EH is often discussed alongside age, although rarely reported in sAHGH dental studies. Where recent studies examined EH, Pfeiffer and colleagues (2019) and Gibbon and Davies (2020) report it to be infrequent, and Gibbon and Davies (2020) suggest its lower prevalence in older adults supports biologically resilient people. Despite the majority of Gibbon and Davies (2020) sample being between 35 and 50 years of age, they found that EH occurred most frequently on the canines and in young adults (11%, 16/102). Van Reenen (1992) mentioned the assessment of 'generalised enamel opacities', as in opaque markers on the enamel in relation to dental wear and the dependent age category variable. These opacities varied considerably in the results, and the author did not elaborate further.

According to Pfeiffer and colleagues (2020), three individuals from childhood to young adulthood already showed 'modest' wear on the molars. These individuals were scored as 'Stage 2' using Smith's (1984) eight-stage system, defined as moderate flattening of the enamel cusps with some pinprick dentine exposure. Pfeiffer and colleagues (2020) mention that by middle adulthood, three adults demonstrated flattened first and second molar cusps and wear patterns reflecting mastication. The molar wear stages ranged between Smith's (1984) stages 6 and 7, where most occlusal surfaces presented partial or complete dentine exposure.

Apart from dental wear age estimation, dental studies that examined cultural behaviour using teeth rarely incorporate age as an assessable variable due to positive correlations between age and wear (Littleton, 2017), making inferences more challenging on smaller sample sets. However, another potential explanation for the lack of attention to age in local studies may be the challenges associated with estimating the age for sAHGH remains (Malek, 2022), thus limiting sample sizes. New observations are nevertheless plausible; for example, Van Reenen (1992) noted that despite the positive correlation between wear and age, the wear rate decreased appreciably once the cusps wore away. Eventually, sAHGH dentition developed an edge-to-edge bite in the anterior teeth, and the jaw accommodated this adaptation through mandibular forward posturing. While this is commonplace for global HGH populations (Kaifu et al., 2003), Van Reenen (1992) surmised that this process expedites for sAHGH in particular, due to the excessively sandy (abrasive) environment (i.e., the Kalahari Desert) they inhabited. Consequently, sAHGH individuals may experience infections and tooth loss sooner due to rapid pulpal exposure, depending on where they spend most of their time.

Impact of spatial regions

Despite the aridity and topography of southern Africa's interior (Lewis, 2008), Sealy and van der Merwe (1988) and Sealy and colleagues (1992) hypothesised that consuming gritty marine foods along the coast may contribute to more wear. Sealy and colleagues (1992) findings supported this observation by noting that the teeth of individuals with higher δ13C values or marine food consumption were slightly more worn than those with lower isotope values, suggesting more mixed, terrestrial diets. Sealy and colleagues (1992) also reported that inland wear (*n* = 5 individuals) was greater in anterior teeth than their coastal (*n* = 44 individuals) counterparts. Although there was no significant difference between inland and coastal individuals, it is noteworthy to mention that isotope studies indicate coastal individuals exhibit considerable variation in the amount of seafood consumed (Sealy et al., 1992), and research recognises they had mixed terrestrial and marine diets from 2000 BP (Pfeiffer & Sealy, 2006). Pfeiffer and colleagues (2020) also acknowledged that greater wear in a coastal sAHGH sample might indicate a diet containing marine components, as individuals of all age groups had moderate wear. Although the study only included 14 individuals, four of whom were infants. According to Gibbon and Davies (2020), coastal dental wear is high, but notably, most of their sample was also coastal (*n* = 133 coastal; *n* = 33 inland).

Oral pathologies such as caries are infrequent along the coast (Van Reenen, 1964, 1966; Sealy et al., 1992; Botha & Steyn, 2015), potentially due to the cariostatic properties of seafood (Sealy et al., 1992). Sealy and colleagues (1992) also noted small-scale regional variation for caries at the site of Oakhurst (*n* = 13), along the southern coast of the Western Cape, where caries occurred in 17.7% of teeth at Oakhurst (34/192 teeth) compared to 8.7% (12/138 teeth) in inland individuals and 2.6% (25/948 teeth) in other south-western Cape coastal individuals (Sealy et al., 1992). The high prevalence of caries at Oakhurst suggests low fluoride content (<2ppm) in the water (Ockerse, 1943), as fluoride is a significant factor for caries incidence (Hillson, 2001). This variation suggested regionality may impact oral health expression for sAHGH teeth, and anomalously carious individuals from the Oakhurst region have since resurfaced in several studies (Patrick, 1989; Sealy et al., 1992; Botha & Steyn, 2015). These observations are interesting partly because archaeologists uncovered some of the oldest sAHGH dentition in this region, and the temporal occupation of these areas is extensive (Black, 2014). This section emphasises regional differences' impacts on sAHGH dental studies, although broader comparisons between coastal and inland patterns on additional oral pathologies are still needed.

<u>Impact of temporal periods</u>

Some studies on sAHGH teeth considered precontact temporal factors: either focusing on tooth morphology and traits (Black, 2014; Irish et al., 2014) or general observations on oral pathology (Pfeiffer, 2007; Black, 2014; Gibbon & Davies, 2020). No known published studies have distinctly included dental wear and pathology and observed interactions against temporal variables. Most recently, Gibbon and Davies (2020) did not find significant differences between pre and post-2000 BP for EH, AMTL, or caries, despite having nearly equal temporal distributions (*n* = 49 pre-2000 BP; *n* = 43 post-2000 BP). The authors did report significant increases in cranial trauma post-2000 BP, suggesting increased stress load from this period. Still, this observation did not translate to aspects such as EH incidence, as EH occurred equally in six individuals for both periods. Infectious lesions were also infrequent when quantified using proliferative lesions and dental infections, demonstrating almost equal incidence rates between pre- (*n* = 16) and post-2000 BP (*n* = 19), which may be due to an enriched microbiome which improved parasitic resilience (Gibbon & Davies, 2020). The latter observations support findings by Pfeiffer (2007), who also reported few infectious lesions, particularly in the middle Holocene. These findings challenge the widely-recognised ‘stressful’ period between 4000 and 2000 BP for sAHGH groups due to resource scarcity, further biologically evidenced through significantly reduced body size (Pfeiffer & Sealy, 2006), as a weakened immune system can encourage infections (Regezi, Sciubba & Jordan, 2017).

As for caries, Black (2014) reported higher incidence rates during the middle Holocene, yet the author drew no further conclusions as additional investigations were beyond the scope of the study. The remarkable thing about these results during the Holocene is that both Irish and colleagues (2014) and Black (2014) reported insignificant results across the Holocene for tooth size and dental trait heterogeneity. These findings suggest dental homogeneity and sAHGH morphological and genetic continuity cranial size fluctuations, where only mandibles demonstrated a slight increase in size for females just before 2000 BP (Ginter, 2011). Consequently, the introduction of herding lifeways from 2000 BP did not bring genetic influence, and population continuity may be assumed. Thus, the morphology of sAHGH teeth remains consistent across the Holocene according to the dental literature, which may reflect the lack of temporal variation in aspects such as dental wear if varying tooth size indeed affects wear quantity rates as proposed by Van Reenen (1964). Therefore, if any observable variations occur in dentition, these are more likely a result of environmental or behavioural variation (Black, 2014), which merits assessments focused on such factors.

Literature considerations

Dental wear direction, trauma, and non-masticatory evidence are broadly unmentioned for sAHGH teeth. Where acknowledged, Van Reenen (1992) mentions rounding in the anterior teeth, likely due to processing materials such as rope and leather, resulting in those teeth not meeting in occlusion. For trauma, any chipping in the molars was caused by breaking nuts and other brittle foods found in the wild, as posterior tooth chipping was more common in the living populations that practised HGH lifeways in the Kalahari, instead of the farm-based groups (Van Reenen, 1992). For non-masticatory evidence in 14 coastal sAHGH individuals, Pfeiffer and colleagues (2020) reported no wear patterns consistent with non-masticatory use of the teeth nor physical manifestations of attempted dental hygiene.

Gibbon and Grimoud (2014) reported on the closest regional analyses of dental wear quantity and direction using the Brabant index on Iron Age Zambian remains. In their study, wear direction elucidated sex differences, elaborating upon possible gender-based use of tools and using teeth as a third hand. Gender-based divisions of labour have been discussed for sAHGH, although using musculoskeletal markers (Churchill & Morris, 1998; Sealy & Pfeiffer, 2000; Pfeiffer et al., 2019). The use of teeth as tools, however, may elucidate possible gender-based labour and can be visible through more detailed analyses of wear patterns as has been possible on global populations (Littleton et al., 2013; Gibbon & Grimoud, 2014; Turner II et al., 2018). Moreover, the Brabant index has not been conducted on any other southern African sample to date, therefore, there is a lack of direct examples using this method in sAHGH literature.

To date, macrowear results and a lower prevalence of dental diseases reported for sAHGH teeth have corresponded with global expectations of dental wear for foraging lifeways as per the ranges reported by Turner II (1979) who remains relevant in the earlier (Sealy et al., 1992) and recent (Towle et al., 2021) sAHGH literature. Sealy and colleagues (1992) sought correlations between dental wear and pathology; however, their study covered three southern African sites, with five individuals representing the interior of southern Africa, and pathological observations only included dental caries. Otherwise, sAHGH dental wear and oral pathological analyses were a technique supporting different overall aims, rather than the aim itself being to systematically assess the interactions between wear and oral health against multiple demographic factors such as age, sex, temporal, and spatial divisions. A study that includes these variables, as intended with this thesis, will contribute to the existing literature by providing an overall understanding of sAHGH diet, behaviour, and impacts across time and space using non-destructive methodologies through the inclusion of demographic impacts as highlighted earlier in this section. This is achieved by further utilising past sAHGH dental research, as summarised here, to clarify what mechanical and physiological dental processes can be a broad expectation in sAHGH teeth, where aspects differ, what dental observations, as supported by the literature to date, warrant smaller-scale assessments. As such, the rationale for conducting this study follows, along with the aims and objectives of this thesis.

2.7 Study rationale

This chapter encapsulated research regarding sAHGH lifeways, bioarchaeological inferences, and the persisting relevance and possibilities for macroscopic methods in dental anthropology. Precontact sAHGH hold a unique position in understanding local and global pasts and HGH behaviour, given their unique and isolated background (Pickrell et al., 2012). Genetically, these individuals are reportedly homogeneous over millennia (Soodyall & Jenkins, 1992; Pickrell et al., 2012), despite southern African environmental and climatic changes (Lewis, 2008) and external population migrations (Iron Age agropastoralists) into southern Africa (Choudhury et al., 2021). Southern African bioarchaeological literature requires a large-scale analysis to elucidate lifestyle and behaviour using sAHGH dentition, as a holistic assessment on a large sample, which exclusively uses multiple macroscopic dental methods and statistically assesses their independent and collective interactions, has not been published upon the date of submission of this thesis. Moreover, global discussions surrounding the discipline encourage the increasing application of biocultural models and the consideration of the osteological paradox (DeWitte & Stojanowski, 2015; Buikstra et al., 2022). Consciously applying these frameworks encourages the reduction of biases through assumptions of nonstationarity and ultimate uniformity across time and space, particularly prevalent in current discussions revolving around sAHGH archaeology (Humphreys, 2007; Pearce, 2012; Pargeter et al., 2016; Forssman, 2019). Such assumptions are also encompassed in current understandings of sAHGH behaviour, considering a holistic assessment that assesses diet and behaviour through a biological element that directly interacts with the environment (dentition), and reflects aspects of health and lifestyle, where certain wear and oral pathologies—dental wear direction, hypoplastic markers, infectious lesions, trauma and non-masticatory wear—and current literature has not extensively discussed their relation to sAHGH behaviour. Integrating multiple lines of evidence is relevant due to the role dental wear plays in predisposing teeth to additional pathologies, which is critical for a population with subsistence strategies contributing to a 'heavy wear' environment.

These data will elucidate any prevalent variation across a wider expanse of time and space and additional variation as required regarding labour and diet (Pfeiffer & Sealy, 2006) through biocultural perspectives on wear and oral health. Further, the findings will be compared to global literature, including research that has utilised the Brabant index on other southern African populations (Gibbon & Grimoud, 2014) and use similar methodologies. Regarding climate changes and chronological developments, there have been periods where southern Africa has demonstrated industry changes (Mitchell, 2002; Sadr, 2015; Lander & Russell, 2020), times of stress (Sealy & Pfeiffer, 2000; Pfeiffer et al., 2019), and possible migration or mobility (Parkington, 2001; Jerardino, 2003; Ginter, 2011; Pfeiffer & Harrington, 2011), and currently, ethnographic records dominate sAHGH data on inland insights (Gibbon & Davies, 2020), and discussions are infrequent due to fewer inland excavations (Morris, 2018). In this study, periods of transition will not be considered moments of crisis but opportunities for sociocultural change and individual adaptation. This line of thought is necessary to contribute to reframing current perspectives on a population that otherwise general understanding considers uniform across space and time (Forssman, 2019) but inevitably demonstrated environmental adaptations as exhibited through biological markers when assessed using a biocultural approach. The literature requires a holistic analysis as per developing social paradigms in southern African sAHGH research. Forssman (2019) highlighted the need for more discussion about hunter-gatherer complexity in southern Africa, where it is already a notable topic of study globally. Therefore, how do discussions about inter-group sAHGH interactions evolve when cultural signals are reportedly poorly-preserved (Forssman, 2019) without understanding the broader limits of sAHGH behaviour in this environment over a rapidly changing period of time (the Holocene) utilising the one skeletal element that interacts directly with an environment? This thesis aims to disseminate knowledge and preserve the past by elucidating sAHGH behaviours and skills as reflected through the biological body's engagement with the environment, rather than through artifacts.

I selected qualitative methods still relevant to bioarchaeology to conduct this investigation, further due to the methods' user-friendliness, where the inclusion of dental wear direction remains novel for sAHGH teeth. These data will be statistically analysed using several techniques that model interactions between multiple variables. The literature has not noted these assessments and statistical applications of the data for macroscopic methods in sAHGH dentition. Further, it considers biocultural frameworks as it allows for observations on the mutual influences of demographic and environmental circumstances and internal behaviours in oral pathology and wear. Moreover, these data elucidate the need to test the reliability of certain methods employed extensively in dental anthropological literature, and this thesis presents a reproduced Brabant index (Chapter 5) that has been accepted and presented at the 48th Annual Meeting of the *Canadian Association for Biological Anthropology* in 2021 indicating the global relevance of contributions within this thesis for the bioarchaeological discipline. This chapter concludes in the next section, which outlines the aims and objectives of this thesis.

2.7.1 Aims and objectives

This study aims to systematically assess dental wear quantity, direction, and oral pathology on archaeological sAHGH dentition, integrating biology with environment using a biocultural approach. The following objectives to accomplish this aim are:

1. Qualitatively investigate and analyse sAHGH sample distribution between demographic variables (sex, temporal, spatial, and age-at-death categorical variables).

2. Assess the reliability of the Brabant index on sAHGH dentition to determine its applicability on ‘heavy wear’ sample sets and optimise the index to reduce subjectivity.
3. Qualitatively investigate and analyse patterns of dental macrowear and oral pathology in a spatial and temporal framework and assess the impact of sex and ages.
4. Critically assess the influence of diet and the environment through a measure of geographic region and time period and their impacts on dental macrowear and pathology using comparative local and global literature, to situate the overall findings within the context of HGH scholarly knowledge.

Where applicable, research questions and testable hypotheses as pertaining to the above objectives include:

1. Are there sAHGH sampling limitations or biases for demographic groupings?
    a. There is no difference between demographic categories when the sample is distributed and compared between sex, temporal, spatial, and age-at-death categorical variables.
2. Are there statistically significant differences between wear score means on the buccal and lingual sides of posterior teeth?
    a. There is no difference between sample means for buccal and lingual dental wear scores.
3. What is the relationship between multiple factors for dental wear and oral pathology in the dentition?
    a. There is no relationship or effect between the predictor variables of wear quantity or wear direction and response variables of tooth type, tooth location, and demographic variables.
    b. There is no relationship or effect between the predictor variables of AMTL, carious teeth and teeth associated with infectious lesions, and the response variables of tooth type, tooth location, and demographic variables.

CHAPTER 3: MATERIALS & METHODS

Dental data were collected from the permanent dentitions of 369 archaeological sAHGH skeletons. A total of 6271 present teeth were examined in addition to the alveolar bone for oral health conditions. All individuals under study were examined for dental macrowear, oral health, sex and age, and all methods applied were non-destructive and non-invasive. The individuals used in this study were obtained from numerous reputable repositories within South Africa**.** Ethics approval from the FHS Human Research Ethics Committee at the University of Cape Town was received (HREC REF# 791/2020; Appendix A: Figure A1), and this research conforms to the National San Code of Research Ethics.

3.1 Materials

The sample involved sAHGH individuals dating to the Holocene (<11,700 to ~500 BP). The studied human remains curated at five institutions were recovered from archaeological contexts suggesting hunter-gatherer and -herder occupation. Institutions included: UCT Human Skeletal Repository, Raymond A. Dart Human Remains Collection, Iziko Museums, National Museum Bloemfontein, KwaZulu-Natal Museum, and unaccessioned individuals from UCT temporarily present in the Archaeology department, UCT and Heritage Western Cape cases temporarily present at the Forensic Anthropology Cape Town laboratory (UCT). Individuals who had not been officially designated sAHGH in the repository archives were included by way of the provenance, burial position and associated material culture and compared with past literature discussing burial characteristics of sAHGH populations (Deacon et al., 1978; Deacon, 1984; Morris, Thackeray & Thackeray, 1987; Morris, 1992a,b; Sealy & Pfeiffer, 2000; Mitchell, 2002; Kusimba, 2005; Forssman et al., 2010; Orton & Halkett, 2010; Sealy, 2010; Orton et al., 2015). Most individuals did not date past 500 BP; however, the few who did (n = 11) from the UCT Human Skeletal Repository had a historical record of maintaining a typical HGH lifeway and previously conducted aDNA evidence of a sAHGH genetic signature which implied absent genetic admixture (Schlebusch et al., 2012).

Spatially, the sample was from the southernmost region of Africa (Figure 3.1), where South African spatial demarcations were set as coastal and in-land. Coastal contexts were within the Cape Fold Belt, with the northernmost region Clanwilliam and the easternmost Gqeberha. Coastal regions external to the Cape Fold Belt were provenances within 20km of the coastline of southern Africa. In-land regions were all interior areas from the Cape Fold Belt or regions additional to the Cape Fold Belt, further than 20km from the coastline (Pfeiffer & Sealy, 2006; Gibbon & Davies, 2020). Temporally, the sample was divided into pre/post-2000 BP, though where possible, the sample was divided further into Holocene divisions that included the earlier (11,700 to 4000 BP), middle (4000 to 2000 BP) and later (2000 BP to ~500 BP) Holocene.

A power analysis suggested a minimum of 15 individuals per group (e.g., temporal or spatial group) at a 95% confidence interval for 80% power when the effect is large (h = 0.8) based on one sample (Cohen, 1988; McHugh, 2008).

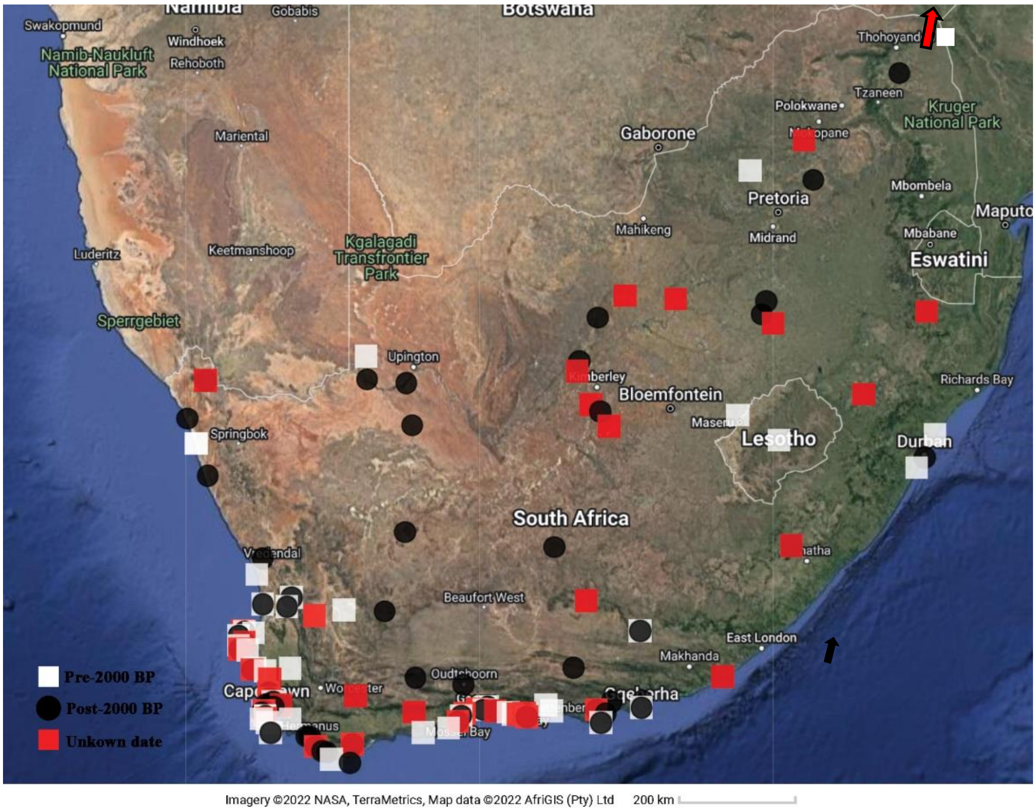


Figure 3.1: Map of southern Africa illustrating distributions of spatial and temporal information for included individuals, adapted from satellite map from Google (2022). The red arrow (upper right-hand corner) indicates the direction of provenances also found further north in Malawi (*n* = 2). This map does not depict individuals with unknown archaeological provenances (*n* = 16). The map is scaled for 1:200. Information for precise number of individuals against general spatial provenances may be found in Appendix B: Table B2.

Study design and criteria

This design for this project was structured as a retrospective study, using qualitative data to observe past socio-cultural phenomena, but with aspects of quantitative analysis through the acknowledgement of a steady increase of wear related to age and dental pathology prevalence throughout life. The data were systematically evaluated to provide an extensive overview of behaviour throughout the Holocene, whereas a correlational research design compares relationships between multiple variables.

Inclusion criteria:

- Archaeological sAHGH individuals.
- Precontact remains dating to the Holocene (11,700 to 500 BP).
- Adult remains (>18 years).
- A minimum of 3 teeth present, where loose teeth are included from fragmentary maxillae/mandibles.
- Fragmentary remains if the dental material is not damaged, weathered or reconstructed to the point of obstructed visibility of features.

A minimum of 3 teeth present was selected to obtain a more precise calculation of frequency means on highly fragmentary remains. Some variables that would otherwise be preferential to include (i.e., demographics) were noted as 'unobservable' as non-dental, scorable elements were unavailable for analyses. Unobservable implies absent, poorly preserved, or poorly reconstructed skeletal elements so that accurate observations may not be drawn from them. This is different from the 'indeterminate' category, which defines the individual's morphological features as too ambiguous to estimate age or sex confidently.

3.1.1 Relevant repositories

Individuals included in the study were sourced from the UCT Human Skeletal Repository, Iziko Museums, National Museum Bloemfontein, Raymond A. Dart Human Remains Collection, and KwaZulu-Natal Museum, and were uncovered from archaeological fieldwork or by accidental discovery. These remains are curated long-term at the repositories for education purposes, encouraging expanding knowledge, and supporting local African narratives (Gibbon & Morris, 2021).

The University of Cape Town

The UCT Human Skeletal Repository is located in the Division of Clinical Anatomy and Biological Anthropology, Department of Human Biology at UCT in Cape Town, South Africa. There are 454 archaeological skeletons in the repository, most are from the Western Cape, and others are represented by South African provenances, whereas 27 are from other southern African nations such as Zimbabwe, Namibia, Nigeria, the Democratic Republic of Congo, and Malawi. Some remains were excavated from sites without detailed records and are thus associated with archaeological material, burial locations, position, and geology to determine archaeological contexts, such as spatial and temporal information (Gibbon & Morris, 2021).

Iziko Museums

Iziko Museums is located in Cape Town, South Africa and houses at least 1200 individuals (Silvester, 2017), representing archaeological remains from the West or South Cape coast of South Africa (Morris, 1992b).

National Museum Bloemfontein

The National Museum Bloemfontein, South Africa, contains a minimum of 575 individuals (Silvester, 2017). A significant portion of the remains were obtained through public accidental discovery and lack precise provenances. The remaining majority were acquired from controlled archaeological excavations from numerous coastal and inland sites (Morris, 1992b).

Raymond A. Dart Human Remains Collection

The Raymond A. Dart Human Remains Collection (Archaeological and Cadaveric) is located in the school of Anatomical Sciences, Department of Health Sciences, at the University of the Witswatersrand, Johannesburg, South Africa. The collection houses a minimum of 2605 archaeological and contemporary individuals (Dayal et al., 2009). Most of the remains were recovered from controlled archaeological excavations and rescue projects (The University of the Witwatersrand, n.d.), although unprovenanced remains make up a portion of the collections (Dayal et al., 2009).

KwaZulu-Natal Museum

The KwaZulu-Natal National Museum, located in Pietermaritzburg, South Africa, houses about 94 individuals, most with local provenances from the KwaZulu-Natal region. More than 70% of the individuals are non-adults or fragmentary adult remains, and most individuals date to the South African Iron Age or contact periods (pre and post-400 AD) (Ribot et al., 2010). The remaining individuals are from the coast of west and east South Africa, with some inland remains (Morris, 1992b).

3.2 Methods

All data were compiled into a complete inventory subdivided between dental macrowear quantity, direction and oral pathology (AMTL, caries, EH, infectious lesions, and dental trauma). Information on the methodology for data collection is outlined below.

3.2.1 Demographic data

This study included non-metric sex- and age-estimation techniques on adult individuals. The selected non-metric methods examine multiple criteria on the skeleton depending on the available elements, including morphological features of the cranium, dentition and post-cranial remains. It is acknowledged that non-metric methods are not without limitations such as observer subjectivity (Bruzek, 2002), age may be underestimated in this study, and where characteristics of sex were ambiguous, the individual was considered indeterminate (see discussion in Chapter 4). Additionally, incomplete remains that only had an inventory of teeth present were included in this study but may not have associated demographic data.

Sex estimation

Sex was estimated from the pelvis and cranium, but the pelvis was prioritised due to the higher accuracy reported from pelvic sex estimation (Işcan and Steyn, 2013; Steyn et al., 2012). Pelvic sex estimation followed protocols by Klales (2012) using features that include the ventral arc, subpubic concavity, ischiopubic ramus ridge and the shape of the pubic bone. The auricular surface size/projection was also examined (Buikstra & Ubelaker, 1994).

Qualitative traits on the skull surface were also examined following protocols described by Buikstra and Ubelaker (1994), as traits can indicate sexual dimorphism and are often used when the pelvis is poorly preserved or absent. A skull with predominantly 'male' characteristics tends to exhibit robustness and sharper edges compared to a skull exhibiting 'female' morphological traits, which appear more gracile and smaller in size. Notably, trait expression along this scale spans a continuum where an overlap exists between sexes. An equal overlap of 'male' and 'female' traits would be indeterminate.

A total of 73 assessed individuals lacked any scorable elements for sex estimation during data collection but had sex catalogued in earlier literature. Therefore, sex estimates for these individuals that were unobservable during data collection were obtained from Black (2014), Campbell (2019), Hausman (1980), L'Abbé and colleagues (2008), Pfeiffer and Sealy (2006), Sealy (2010), and Stynder and colleagues (2007) (Appendix C: Table C1).

Age-at-death estimation

Age-at-death was estimated using non-metric methods based on characteristics that vary in form due to degenerative, developmental and ageing processes (Adserias-Garriga & Wilson-Taylor, 2019). Depending on available remains for the ribs, pelves, dentition, and crania, multiple methods were used. Age-estimation methods included sternal rib ends (Işcan & Loth, 1986a,b; Oettlé & Steyn, 2000), the morphology of the auricular surface (Buckberry & Chamberlain, 2002) and the pubic symphysis (Brooks & Suchey, 1990) of the pelvis, third molar eruption (Esan & Schepartz, 2018), and where only crania were available, cranial suture closure (Meindl & Lovejoy, 1985). These are explained in detail further below. Due to the variety of preserved and present remains available for scoring, age was estimated based on a combination of the abovementioned methods that resulted in broad categories of young (YA = 18-35 years), middle-aged (36-49 years) or old adults (>50 years). Additional groupings of young/middle and middle/old adults between age phases refer to individuals with age-at-death estimates that extend across more than one of the defined age categories. There are no current standards for sAHGH age estimation; these age categories were based on the broad groupings for age estimation for sAHGH individuals from Malek (2022). Furthermore, additional age categories included indeterminate, where the individual's age spanned more than three categories, and unobservable, where scorable elements are either absent or poorly preserved. The techniques used for age estimation are discussed in detail below.

Sternal rib end age estimation within this study followed multiple studies that have used the same method on varying populations (Işcan & Loth, 1986a,b; Oettlé & Steyn, 2000) and all examine pit depth, shape, rim and wall configuration of the fourth rib, and if necessary, the third, fifth or sixth rib can be used. Scoring systematic age-related changes on the pelvis was completed by assessing the auricular surface using methods outlined by Lovejoy and colleagues (1985). The symphyseal surface of the *os pubis*, commonly referred to as the pubic symphysis, was scored for age-related changes relative to its appearance, shape and size using the Suchey-Brooks method (Brooks & Suchey, 1990), a technique typically used alongside methods on the auricular surface. Only adult individuals were included; thus, the only erupting tooth that would be pertinent was the third molar for dental age estimation using the WITS Atlas (Esan & Schepartz, 2018). Notably, uneruption, delayed eruption or congenital absence of the third molars is possible (Molleson & Cohen, 1990; Nelson, 2015; Esan & Schepartz, 2018); therefore, third molar eruption is ideally used alongside additional age-at-death methods. Cranial suture closure was conducted to determine an age estimate using ten ectocranial suture sites, which include vault and lateral-anterior locations, as outlined in Buikstra and Ubelaker (1994). Cranial sutures generally fuse as an individual ages, where the composite scores determined from each degree of suture closure can suggest an age estimate. However, the accuracy of age estimation through cranial sutures has been contested (Garvin et al., 2012) but is used when no other options are available. Due to the expected fragmentary nature of the remains, cranial suture closure was included in this study as a final resort.

3.2.2 Dental inventory

Tooth expression criteria included: present, AMTL, and unobservable due to postmortem loss, missing (absent tooth and mandible/maxilla), or completely broken teeth (non-pathological). The teeth were recorded using FDI notation (ISO 3950 numbering system) as designated by the International Organization for Standardization and used by the World Health Organization (WHO) (Figure 3.2). The teeth were also presented in their abbreviated written form as tooth types in groups of incisors, canines, premolars and molars and were further separated into quadrants of the dental arcade to account for the right side, left side, maxillary (upper) and mandibular (lower) regions. A ‘missing’ tooth indicated the tooth’s complete absence and the bone segment in which it would have been rooted. A ‘missing’ classification may be due to post-excavation handling, taphonomic processes, or previous destructive sampling. ‘Unobservable’ observations, where present, indicated the presence of the tooth but its obstructed visibility due to the aforementioned extrinsic reasons.

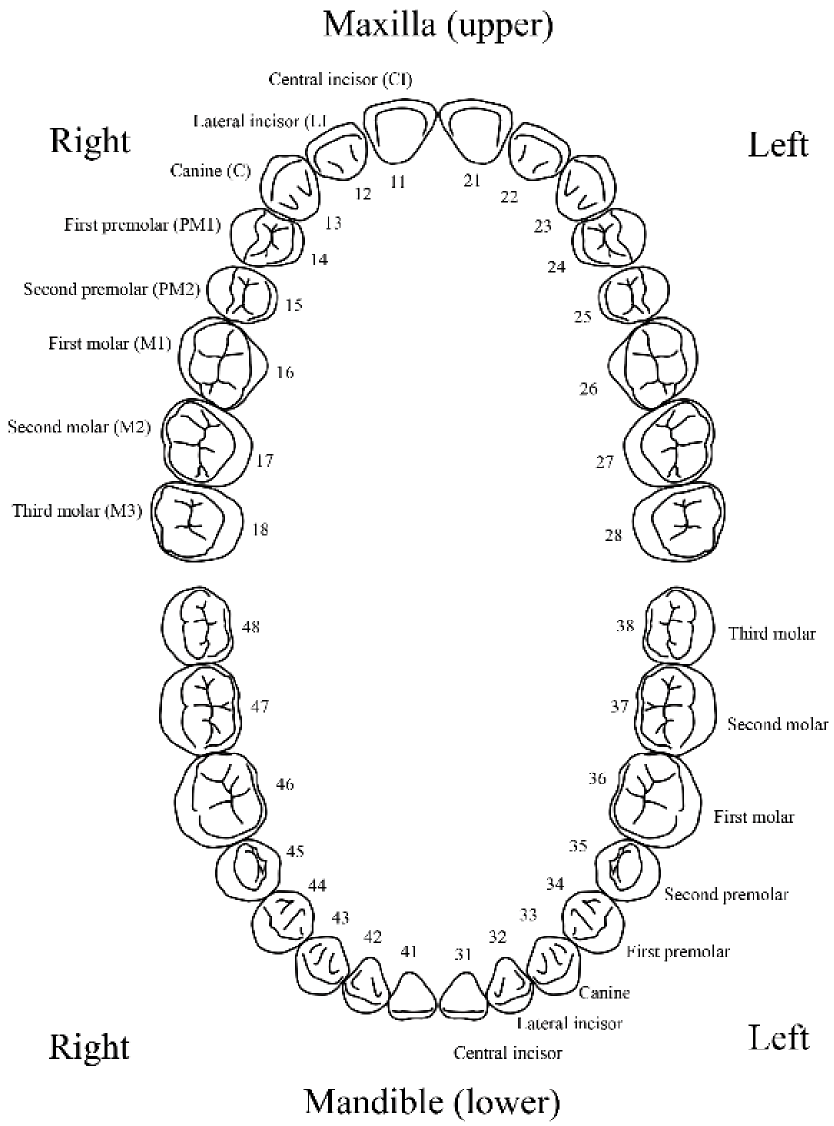


Figure 3.2: World Dental Federation notation for human teeth with individual tooth type names. Image created by author.

3.2.3 Dental macrowear: Brabant index

Macrowear was scored for quantity and direction using the Brabant index (Brabant, 1966), a qualitative scoring system that uses five stages for each tooth (Table 3.1). Regarding quantity assessments, the Brabant index observes the overall loss of enamel and the amount of dentine exposed. For direction, macroscopic characteristics of the type of wear on the tooth surface are examined. A Brabant index visual guide was created and digitised by the author in Adobe Photoshop 2020 (version 21.0.2) and Adobe Illustrator 2020 (version 24.0) to mitigate subjectivity bias when using the method and is presented in Chapter 5.

Table 3.1: Brabant index dental wear quantity and direction stages.

Brabant index: Dental wear quantity and direction		
Stage	**Dental wear quantity**	**Dental wear direction**
0	Absence of wear	Absence of wear
1	Visible on enamel; enamel polishing	Horizontal and plane
2	Dentine partially exposed in clusters	Horizontal and concave
3	Dentine completely exposed	Oblique and plane
4	Advanced wear; exposing pulp chamber	Oblique and concave

3.2.4 Oral conditions

Oral conditions were identified using macroscopic analyses, and multiple lesions were recorded for presence/absence, frequency, anatomical location, orientation and size, where pertinent. Pathologies prioritised for this study are AMTL, caries, EH, infectious lesions, and dental trauma. Any additional pathological conditions, malpositioned teeth, or deviations from the norm (e.g., hyperdontia, mandibular tori) were described and photographed.

AMTL was identified if the alveolus showed signs of healing through bone remodelling, demonstrating partial or complete resorption of the alveolus (Lukacs, 1995), unlike post-mortem tooth loss, which presents as a gaping socket with no sign of new growth. Caries were identified if there was a visible erosional pit on the tooth, where the defect had irregularly demineralised the dental tissue, thus, had entered the dentine or pulp canal (Hillson, 2008). For this study, discolouration on the tooth surface was not scored as carious due to the difficulty in determining whether the lesion was carious, traumatic, or a hypoplastic opacity without radiographic evidence (Slayton et al., 2001; Seow, 2014). Multiple carious lesions on a single tooth were recorded as well as the frequency of carious teeth per individual. Individual carious lesions were classified by their location and orientation: coronal, CEJ, root; occlusal, mesial, distal, buccal, lingual, gross and interproximal (Buikstra & Ubelaker, 1994; Hillson, 2001; Temple, 2016; Carter & Irish, 2019). Gross caries, wherein a lesion destroys most of the crown (Hillson, 2001; Temple, 2016), was an obstruction of visibility for additional dental wear scoring. EH was recorded for expression, location, type (linear, pitting), frequency, and distance from CEJ measured with digital vernier callipers (Buikstra & Ubelaker, 1994); however, only analysing the expression and frequency of EH was within the scope of this study. A dental chart (Figure 3.3) was used to visually note the anatomical orientation and location of caries and EH on the tooth and the presence and absence of teeth. Any additional dental or oral conditions were identified, recorded, described and photographed. For all pathological conditions, the condition was recorded as 'unobservable' if visibility was poor due to heavy calculus, heavy taphonomic damage, past reconstruction efforts, or postmortem breakage.

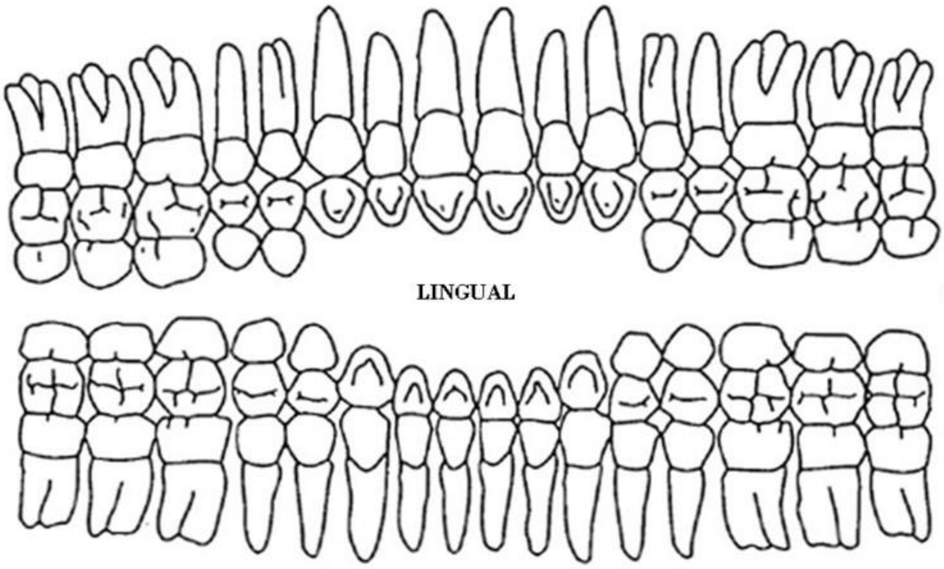


Figure 3.3: Blank dental chart example to mark tooth and pathology expression on the entire dental arcade, adapted from The University of Arizona (2018: 3a–2).

Infectious lesions

Infectious lesions were diagnosed macroscopically following archaeological guidelines as outlined by Dias and Tayles (1997), Dias and colleagues (2007), Nikita (2017), and Rufino and colleagues (2017); therefore, lesions had to perforate the cortical bone to be recorded. Where possible, loose teeth with preserved sockets were carefully removed to examine the alveolar socket for additional infectious cysts (Rufino, Ferreira & Wasterlain, 2017). Scoring for the presence and type of infectious lesion were completed through descriptive characteristics of the lesion's form and size measured in millimetres with electronic callipers. The criteria used were a combination of the abovementioned methods and are as follows:

1: Cyst, smooth walls ≤3mm.
2: Cyst, smooth walls >3mm.
2: Primary, chronic abscess, rough edges ≤3mm.
3: Chronic osteomyelitis, rough bone, irregular shape and size.

Visible fistulae were also recorded. Notably, infectious lesions were scored on a reduced sample size, only including remains from the Human Skeletal Repository UCT and Iziko Museums, as method criteria were refined in 2021, and it was not possible to revisit collections outside the Western Cape province (Raymond A. Dart Archaeological Human

Remains Collection; National Museum Bloemfontein; KwaZulu-Natal Museum) due to travel limitations, which included intermittent National lockdowns as issued by the South African Government during the National State of Disaster from 2020 to 2022 (Government of South Africa, n.d) as well as funding limitations to revisit collections.

Dental trauma

Dental trauma was recorded if chipping, fracturing, or non-masticatory wear markers (i.e., tool use) was observed. Totals were calculated as the frequency of chips and chipped teeth per individual. Recording pathological dental trauma followed procedures as outlined by multiple authors (Bonfiglioli et al., 2004; Belcastro et al., 2007; Scott & Winn, 2011) and the combined criteria used for this study are as follows:

(1) Degree:
Grade 1: Slight crack with superficial enamel flake loss.
Grade 2: Square irregular lesion involving enamel (up to dentine).
Grade 3: Large irregular fracture involving enamel and dentine or a large crack that may destroy the entire tooth.
(2): Number of chips per tooth.
(3) Location quartered per cusp (e.g., distolingual cusp, mesiobuccal cusp).
(4) Other: Accidental dental modification due to behavioural wear from tool usage, analysed by description due to various possible forms.

To identify antemortem dental trauma, the tooth should lack radiating infraction lines running throughout the enamel (Lukacs & Hemphill, 1990; Milner & Larsen, 1991; Gibbon et al., 2018) and evidence of postmortem chipping, which usually appears sharp-edged and irregular (Buckberry & Chamberlain, 2002). Non-masticatory wear or intentional dental modification, if present, would be identified via descriptive characteristics of the shape of the modification. The modification would be compared to past literature that has reported on dental modification (Shaw, 1931; Fagan, 1967; Briedenhann & Van Reenen, 1985; Van Reenen & Briedenhann, 1986; Jones, 1992; Morris, 1998; Friedling & Morris, 2005; Gibbon & Grimoud, 2014; Pinchi et al., 2015) or to unique patterns from possible parafunctional habits (Minozzi et al., 2003; Bonfiglioli et al., 2004; Erdal, 2008; Ricci et al., 2016; Stojanowski et al., 2016).

3.3 Data analyses

Variables classified as unobservable or indeterminate were grouped as statistically missing values. All data for this study were recorded into a database created for this project in Microsoft® Excel® for Microsoft 365 MSO (version 2204). Statistical analyses were performed using IBM© SPSS Statistics for Windows (version 28.0.1; IBM©, 2022) and R (version 4.1.3; R Core Team, 2022). All the qualitative data were coded for use in IBM© SPSS and R, and descriptive and inferential statistics were conducted to analyse the data. All alpha values (*p* values) were tested at a 95% confidence level, where values of less than or equal to 0.05 ($p \leq 0.05$) indicate a significant statistic.

3.3.1 Reliability assessments

Macrowear quantity and direction were scored thrice on 40 randomly selected individuals to evaluate inter- and intra-observer accuracy, first with the original Brabant index method and then again with a modified version with a visual guide. Inter-observer tests were completed for dental wear using two different objective observers at three-week intervals, where the first participant had little experience with teeth and the second participant had sufficient experience with teeth. Dental pathology expression (caries, AMTL, EH) was scored twice on the same randomly selected individuals. The author collected age and sex data, but where possible, data were also acquired from another project by a 2021 Master of Philosophy student, Sadiyah Malek. Inter-observer reliability assessment for age estimation was completed on 32 randomly selected individuals and on 34 randomly selected individuals for sex estimation. Information on the randomly selected individuals for reliability assessments were undisclosed to the interrater. Collecting the data for this assessment was completed before data collection to mitigate the degree of observer bias. Macrowear ratings were assessed for ordinal data using a weighted Cohen's kappa (wKappa), and pathological expressions were assessed using Cohen's kappa.

By foundation, the Kappa statistic assesses *achieved* beyond-chance agreement as a proportion of the *possible* beyond-chance agreement for the presence or absence of a variable on a nominal scale (Sim & Wright, 2005):

$$k = \frac{observedagreement - chanceagreement}{1 - chanceagreement}$$

A wKappa, however, considers categories that are further apart or have meaningful differences, thus, assigning less weight to agreement and instead measuring the degree of disagreement using a predefined table of weights (Cohen, 1968; Viera & Garrett, 2005). wKappa criteria are based on linear weighting for agreement because there is the same importance of the difference between the first and second categories as with, for example, the second and third categories. When interpreting a kappa coefficient, according to Cohen (1968)**,** the kappa statistic is interpreted as values of ≤ 0 indicate no agreement, 0.01-0.20 as none to slight, 0.21-0.40 as fair, 0.61-0.80 as substantial, and 0.81-1.00 as strong agreement. However, the current literature recommends 0.80 to be considered the minimum acceptable interrater agreement (McHugh, 2012). Alongside the obtained value of kappa, it is also recommended to demonstrate the confidence interval (CI) for each kappa result to reflect sampling error (Sim & Wright, 2005).

3.3.2 Statistical assessments

Chi-Square Tests of Independence were conducted to assess significant differences in the frequencies regarding sample distribution for individuals with demographic classifications (sex, age-at-death, spatial, pre/post-2000 BP, and Holocene divisions) and distributions of the data due to chance or due to a relationship between the variables under study. The test applies an approximation assuming that less than 20% of the cells have expected frequencies of less than 5 (≤5) and no cell has an expected frequency of less than 1.1 (≤1.1). Where the frequency of individuals within a demographic category was too low (≤5), a Fisher's exact test and Fishers Freeman-Halton exact test were conducted to assess for independence between two or more variables when the comparing groups were independent and uncorrelated. These tests are a type of exact tests, which are used as opposed to approximation. This is due to approximation being inadequate for small sample sizes; more than 20% of the cells must have an expected frequency of ≤5.

A logistic regression test was conducted to assess any effects of varying factors (demographics, dental arcade and tooth type) on pathology expression and dental wear scores. Logistic regression uses categorical variables to acquire an odds ratio (OR) for each predictor variable, to examine the effect of a particular variable using the outcome of the test. OR is expressed as no effect being 1, implying the effect occurred by chance alone, and anything ±1, up to infinity or 0, represents a decreasing or increasing effect (Bartholdy et al., 2020). Logistic regression functions similarly to linear regression, except a logistic regression maintains linearity in nonlinear categorical data by transforming the outcome variable. The process in this study occurs by a chosen probability scaled by the presence or absence of a chosen pathology or frequency of a wear stage, and factors are used to calculate the likelihood of observing the independent variable in all the cases. Once those likelihoods are multiplied, the result becomes the likelihood of the data given the logistic line, to which this process is repeated by shifting the line until the curve with the maximum likelihood is selected. Based on the data at hand, the test generates a model that maximises the probability of an outcome, or in other words, calculates the coefficients of the equation using the maximum likelihood. Logistic regression is beneficial because more than two explanatory variables can be examined simultaneously, compared to multiple explanatory variables observed independently, which ignores the covariance among variables and subjects the results to confounding effects (Sperandei, 2014; Bates et al., 2015; Bartholdy et al., 2020). In sum, logistic regression can classify samples (e.g., caries present or caries absent) against different types of data (e.g., maxillae, mandibles, and demographics). The test then assesses which variables are useful for further classifying samples, whether a variable is significant to include, or if it can be excluded to improve the model's best fit.

Where Akaike's Information Criterion (AIC) is presented, this figure reflects the likelihood of conformity of the model to the data being assessed. The AIC is an estimator of prediction error, and when processing different data models, it estimates the quality of each model to the other models and provides a mean of model selection. In sum, the AIC demonstrates the model of best fit by adapting to the nuances of the data and aids in model selection (Cavanaugh & Neath, 2019)

Oral health

Logistic generalised linear mixed-effects models were conducted for AMTL, caries, and infectious lesions to assess the hypothesis of whether numerous factors affect the expression of the mentioned oral condition. The glmer function of the lme4 package (version 1.1.28; Bates et al., 2015) was used in R (version 4.1.3; R Core Team, 2022) to assess the incidence of pathology, with the individual term being the random effect.

Dental wear

Means were calculated for dental wear quantity scores to evaluate the overall average of wear on a continuum for the total sample and between demographics to compare against past studies that presented mean quantity. A paired *t* test was conducted between buccal and lingual means to assess whether separate scoring demonstrated significance. Chi-Squared Test of Independence were conducted for the frequency of dental wear scores on maxillae and mandibles for quantity and direction to assess differences in the frequencies and distributions of the data among demographic categories. This would determine whether a bias exists for the frequency of scored surfaces for maxillae or mandibles within a demographic category.

A cumulative link mixed model fitted with the Laplace approximation formula was performed using R (version 4.1.3; R Core Team, 2022) to assess the effects of factors on dental wear quantity. The individual term remained the random effect, and the test was conducted to analyse the ordinal response of the dependent variable (dental wear quantity) against the independent predictors (demographic groups, arcade, tooth type). A cumulative link model uses ordered but non-continuous ordinal response data and assumes the effect of the predictors are independent of the ordinal response (Schmidt, 2012).

Multinomial logistic regression was conducted with IBM© SPSS Statistics to assess the effects of numerous factors on dental wear direction. The individual term remained the random effect, and the test was conducted to determine if interactions exist between independent variables (demographic groups, arcade, tooth type) to predict the dependent variable (dental wear direction) measured at the nominal level. Like the abovementioned ordinal logistic regression, a multinomial logistic regression is an extension of a standard logistic regression; however, the multinomial test allows for more than two categories of the dependent or outcome variable (Kwak & Clayton-Matthews, 2002).

CHAPTER 4: THE SAMPLE RESULTS & DISCUSSION

This chapter includes study sample results and discussion. Inter-observer assessments were conducted for age and sex and are first presented, followed by overall sample distribution and the demographic distribution for each included variable (sex, age, spatial, temporal). The final sections of this chapter include discussions on the sample distribution and representation with acknowledgements of any limitations or biases relevant to additional analyses.

4.1 The study sample

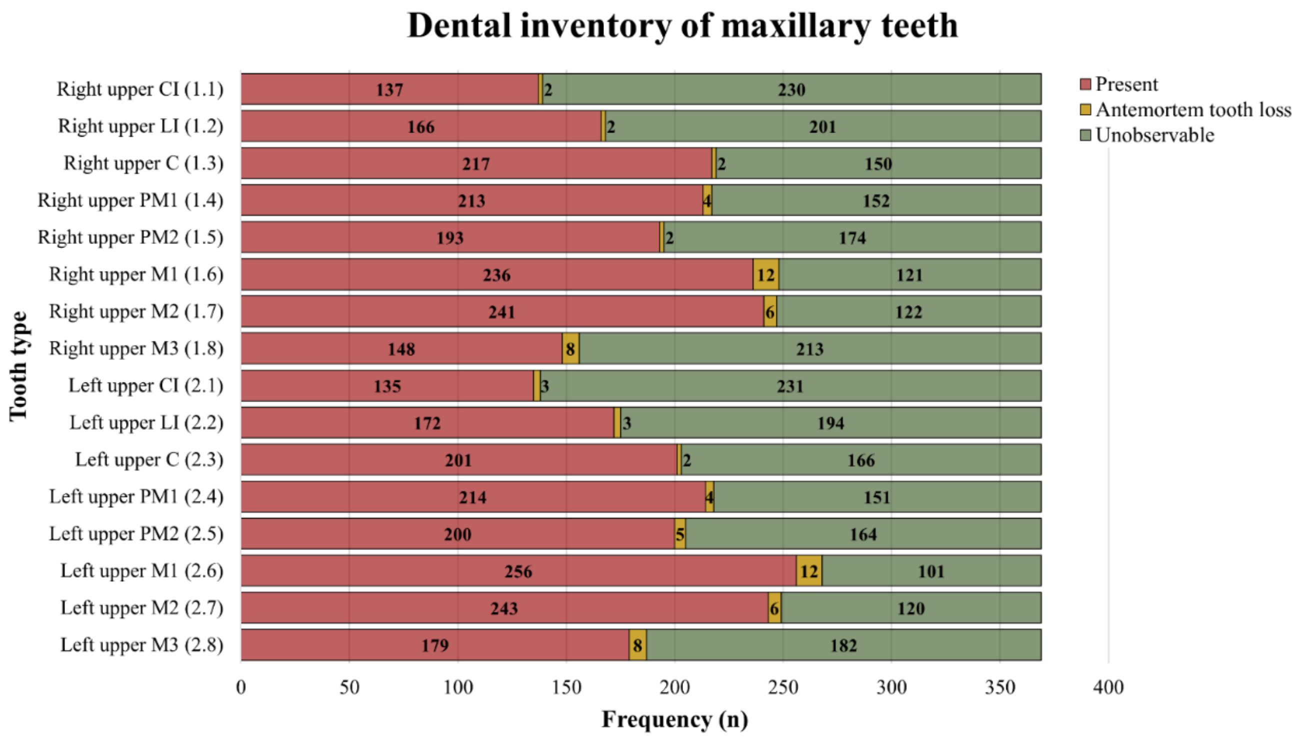
A total of 369 individuals from five repositories met the criteria for inclusion in this study, 39% from the UCT Skeletal Repository, 37% from Iziko Museums, 11% from the Raymond A. Dart Archaeological Collection, 11% from the National Museum Bloemfontein, and 2% from the KwaZulu-Natal Museum (Table 4.1).

Table 4.1: Study sample distribution divided by the repository.

Skeletal Repository	***n***	**%**
University of Cape Town Skeletal Repository† (Cape Town)	145	39
Iziko Museums (Cape Town)	136	37
Raymond A. Dart Archaeological Collection (Johannesburg)	41	11
National Museum (Bloemfontein)	41	11
KwaZulu-Natal Museum (Pietermaritzburg)	6	2
Total	369	100

n = sample size
†Of the 145 individuals from UCT, 130 were derived from the UCT Skeletal Repository in the Faculty of Health Sciences, and 15 were unaccessioned individuals temporarily curated either at UCT's Department of Archaeology or UCT FACT Lab.

Figure 4.1 presents the dental inventory for all individual teeth as indicated by their particular tooth type and FDI notation, and the sample size encompasses the frequency of the inventory. There were 369 analysed individuals with 6271 teeth present for analysis, 208 were lost antemortem, and 5329 were unobservable due to post-mortem damage or loss. There was a nearly equal distribution of tooth presence between the maxillary and mandibular dental arches and between the left and right sides of the dental arcade. More teeth were lost antemortem in mandibles than maxillae, where 61% (127/208) of total AMTL were in mandibles compared to 39% (81/208) in maxillae. However, there was a nearly equal distribution of AMTL between the right and left sides of the dental arcade. Like present teeth, unobservable teeth were almost equally distributed across the dental arcade, between maxillae and mandibles, and between the right and left sides of the dental arcade.



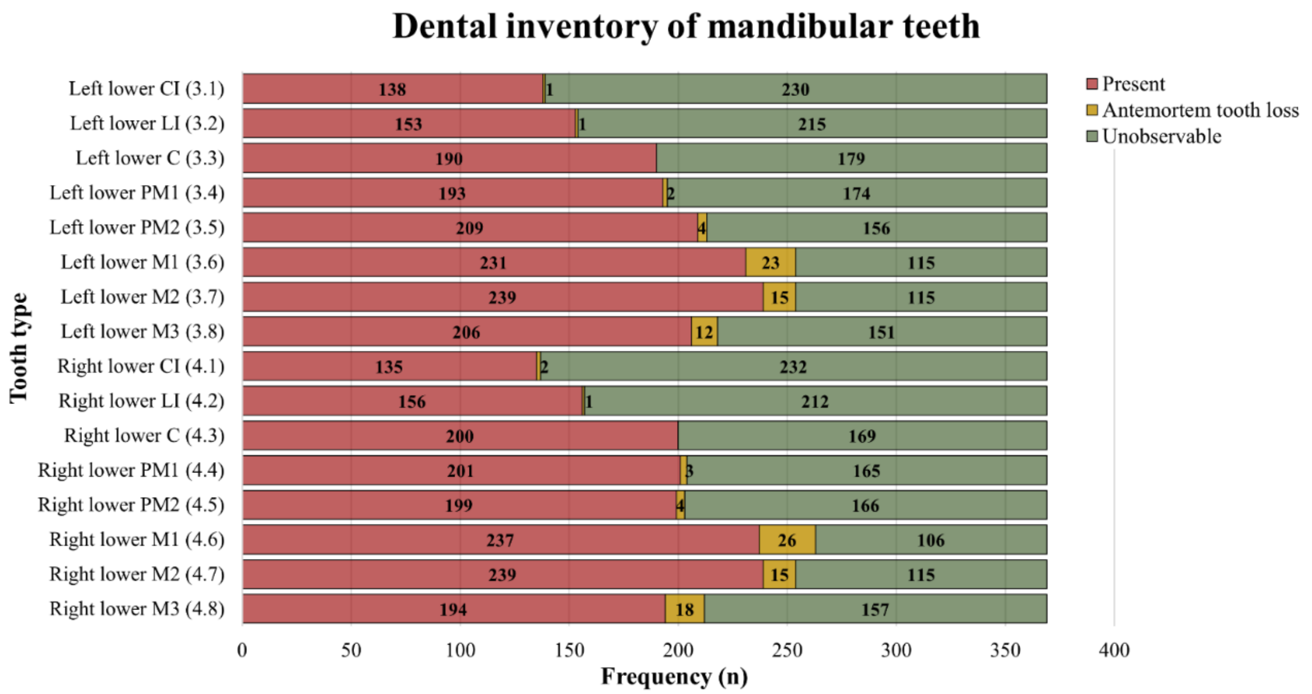


Figure 4.1: Dental inventory for maxillary teeth (top) and mandibular teeth (bottom). Tooth types are indicated in written type and numerical notation.

4.1.1 Method repeatability

Inter-observer reliability assessments for age and sex estimation are presented in Table 4.2 as determined by Cohens Kappa. The results were of strong agreement between the author and observer 1, with 0.92 for age estimation and 0.94 for sex estimation.

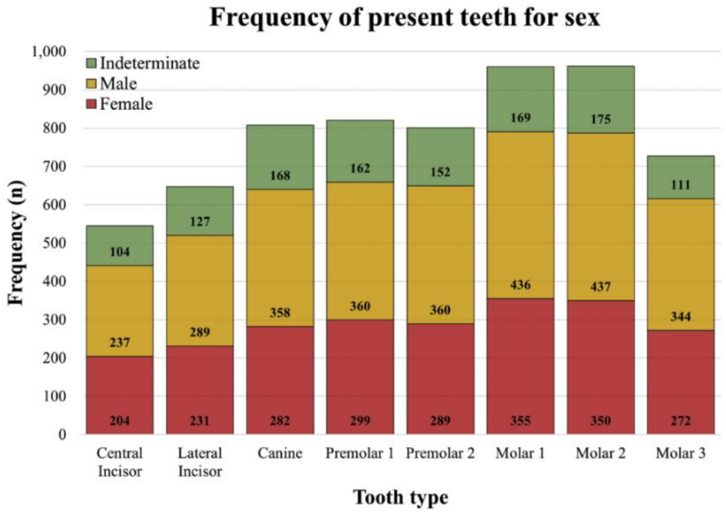
Table 4.2: Inter-observer Cohen's kappa result for age and sex estimation.

Test	Variable	Age and sex estimation Kappa	95%CI†
Inter-observer assessments	Age estimation	0.92	0.76 – 1.00
	Sex estimation	0.94	0.84 – 1.00

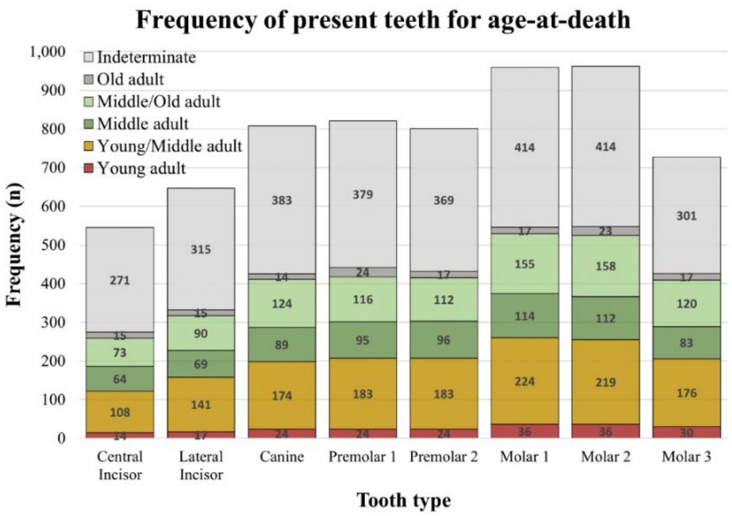
†95%CI is the confidence interval at 95%, demonstrating the lower and upper CI range.

4.1.2 Demographic profile

Individuals cross-tabulated between demographic variables are in Tables C3 and C4 (Appendix C). A complete overview of teeth against the demographic variables of sex, age, spatial, and temporal divisions, including present teeth, lost antemortem, and unobservable, are presented in Table C5 (Appendix C). Figures 4.2 and 4.3 demonstrate the frequency of teeth present for all demographic variables, and do not include any teeth lost ante or postmortem. Whereas Figures 4.4 and 4.5 illustrate the relative frequency of teeth present in percentages for all demographic variables. Demographic variables regarding present teeth are discussed further in the subsequent sections.

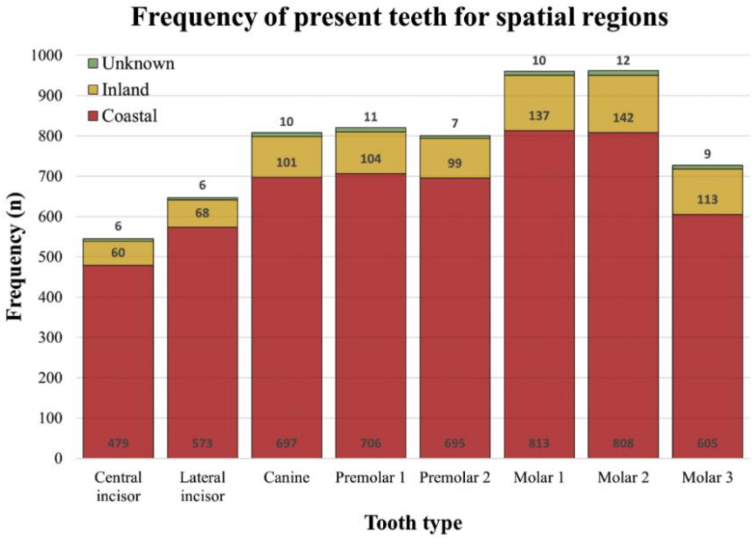


	Frequency of present teeth	
	# of Individuals	# of Teeth
Variables	***n (%)***	***n (%)***
Sex		
Female	131 (54)	2282 (55)
Male	153 (46)	2821 (45)
Total sexed	**284 (77)**	**5103 (81)**
Indeterminate	85 (23)	1168 (19)
Total	**369**	**6271**

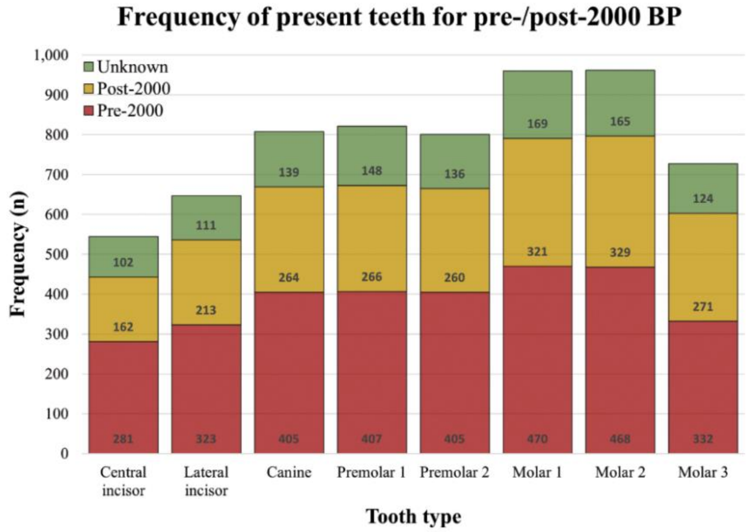


	Frequency of present teeth	
	# of Individuals	# of Teeth
Variables	***n (%)***	***n (%)***
Age-at-death estimate		
Young adult	11 (6)	205 (6)
Young/middle adult	71 (38)	1408 (41)
Middle adult	40 (21)	722 (21)
Middle/old adult	58 (31)	948 (28)
Old adult	9 (5)	142 (4)
Total aged	**189 (51)**	**3425 (55)**
Indeterminate	180 (49)	2846 (45)
Total	**369**	**6271**

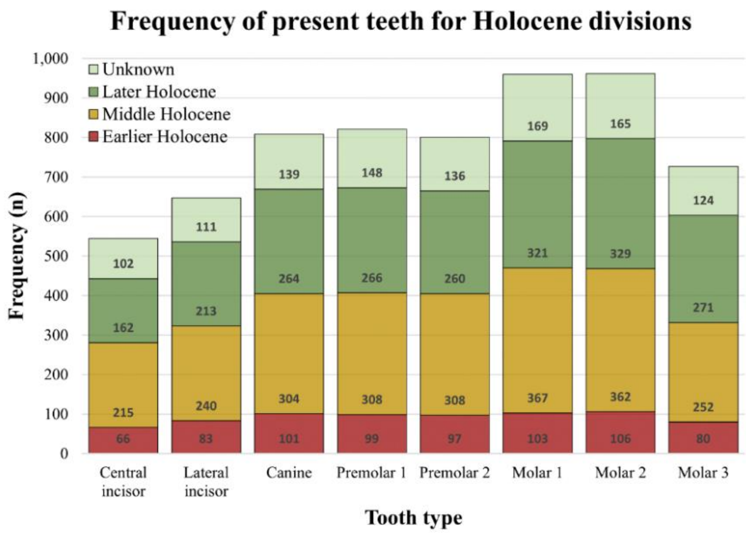
Figure 4.2: Frequency of present teeth for all demographic variables and tooth types for sex (top) and age-at-death (bottom). Table percentages are calculated against total with an estimate and unknown percentages against total sample.



	Frequency of present teeth	
	# of Individuals	# of Teeth
Variables	***n (%)***	***n (%)***
Spatial regions		
Coastal	314 (87)	5376 (87)
Inland	49 (13)	824 (13)
Total with provenance	**363 (98)**	**6200 (99)**
Unknown	6 (2)	71 (1)
Total	**369**	**6271**



	Frequency of present teeth	
	# of Individuals	# of Teeth
Variables	***n (%)***	***n (%)***
Pre-/Post-2000 BP		
Pre-2000 BP	187 (62)	3091 (60)
Post-2000 BP	114 (38)	2086 (40)
Total dated	**301 (82)**	**5177 (83)**
Unknown	68 (18)	1094 (17)
Total	**369**	**6271**



	Frequency of present teeth	
	# of Individuals	# of Teeth
Variables	***n (%)***	***n (%)***
Holocene divisions		
Earlier Holocene	50 (17)	735 (14)
Middle Holocene	137 (46)	2356 (46)
Later Holocene	114 (38)	2086 (40)
Total dated	**301 (82)**	**5177 (83)**
Unknown	68 (18)	1094 (17)
Total	**369**	**6271**

Figure 4.3: Frequency of present teeth for all demographic variables and tooth types for spatial (top), pre/post-2000 BP (middle) and Holocene divisions (bottom). Table percentages are calculated against total variable, and unknown percentages against total sample.

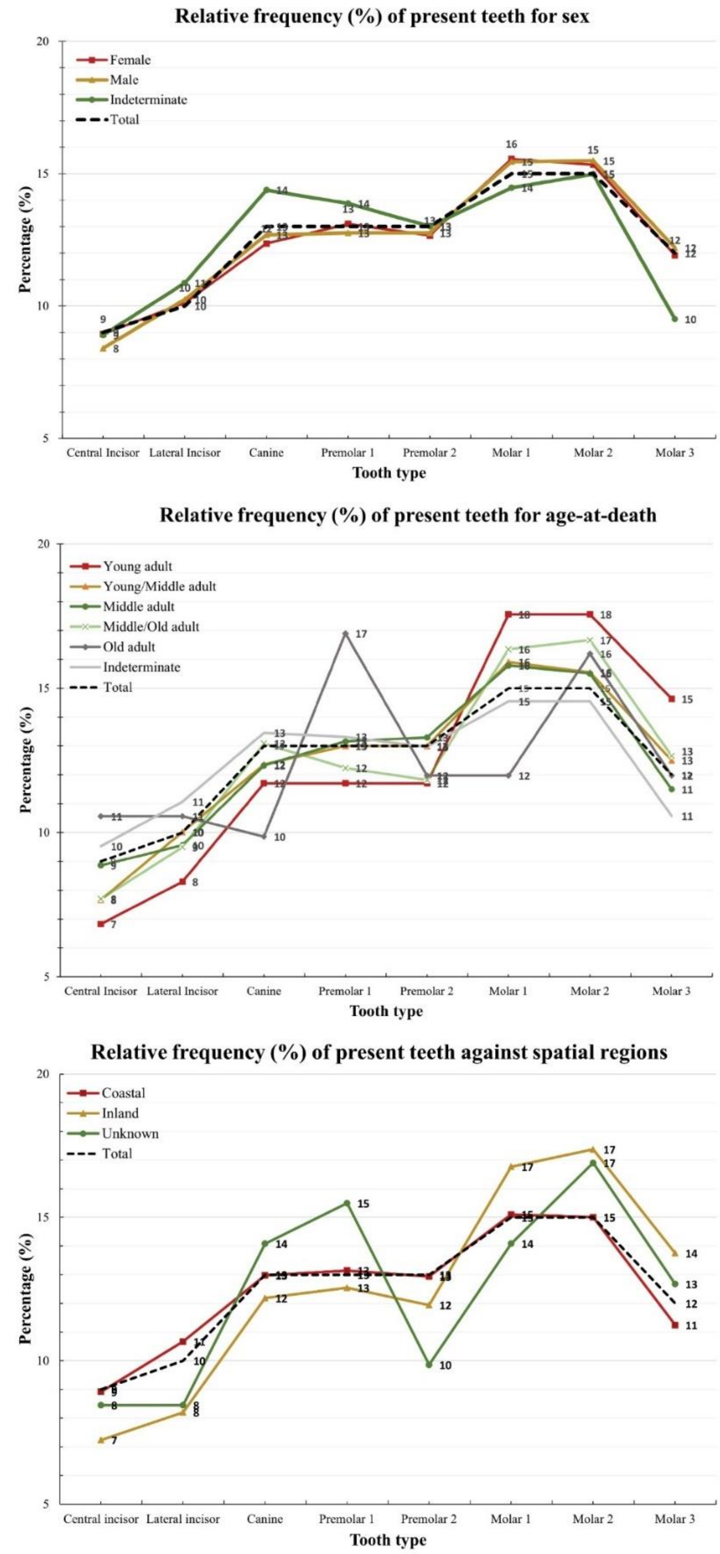


Figure 4.4: Relative frequency expressed as percentages of present teeth, from top to bottom, for sex, age, and spatial regions. Age (middle) presented a similar distribution except for variation in old adults against other categories due to the small sample size. Spatial (bottom) demonstrated a similar distribution, although variation with unknown spatial divisions may be relative to a small sample size. For all graphs, ‘total’ represents the total percentage of tooth types against the entire sample.

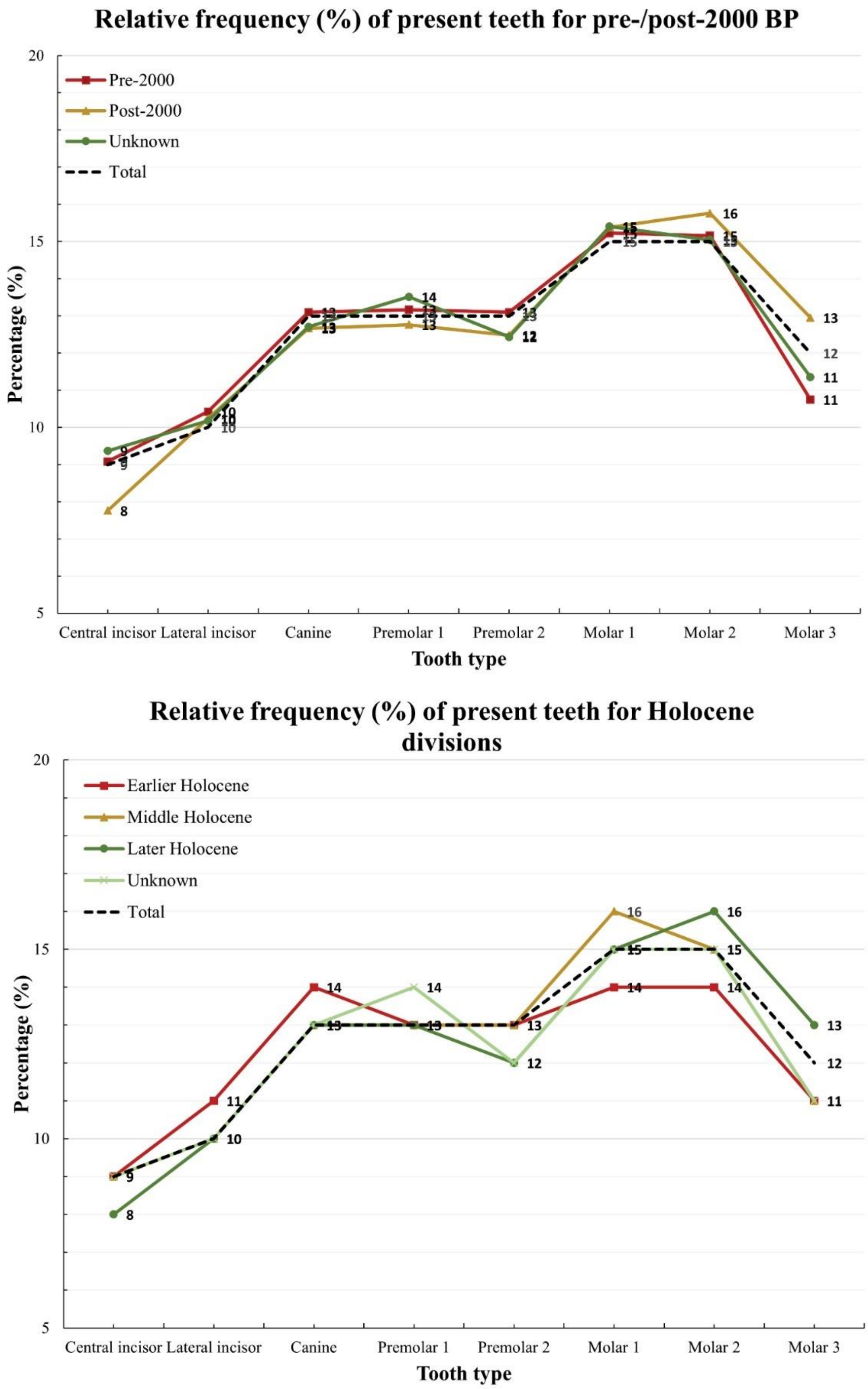


Figure 4.5: Relative frequency expressed as percentages of present teeth, from top to bottom, for pre/post-2000 BP and Holocene divisions. In all graphs, ‘total’ represented the total percentage of tooth types against the entire sample.

4.1.2.1 Sex and age distributions

Tables 4.3 and 4.4 present the distributions of sex and age as demonstrated by tooth type for teeth present, excluding teeth lost ante or postmortem. Figure 4.2 presented the frequency, and Figure 4.4 illustrated the frequency in percentage of sex and age (respectively) for all tooth types to demonstrate the close distribution of each tooth type group for each variable**.** Overall, 77% (284/369) of individuals had a sex estimate possessing 81% (5103/6271) of teeth present, while the remaining 23% (85/369) of individuals were unobservable, including 19% (1169/6271) of teeth. Of sexed individuals, there was a slightly higher representation of males, representing 54% (153/284), followed by females representing 46% (131/284). Regarding teeth present for sexed individuals, 55% (2821/5103) of total present teeth were from males and 45% (2282/5103) from females. Figure 4.6 illustrates the equal distribution across maxillae and mandibles when comparing males and females.

Age was estimated for 51% (189/369) of individuals, including 55% (3425/6271) present teeth, and 49% (180/369) of the sample was unobservable for age, including 45% (2846/6271) of teeth. Young adults represented 6% (11/189), young/middle adults represented 38% (71/189), middle adults represented 21% (40/189), middle/old adults represented 31% (58/189), and old adults represented 5% (9/189). Of teeth present from aged individuals, 6% (205/3425) were from young adults, 41% (1408/3425) from young/middle adults, 21% (722/3425) from middle adults, 28% (948/3425) from middle/old adults, 4% (142/3425).

Table 4.3: Distribution of present teeth for each tooth type against sex, relative frequencies calculated against total present teeth to demonstrate relative distribution for the total sample.

		Frequency of present teeth for sex			
		Female	**Male**	**Indeterminate**	***Totals***
Variables		***n (%)***	***n (%)***	***n (%)***	***n (%)***
Tooth type†	Central Incisor	204 (9)	237 (8)	104 (9)	*545 (9)*
	Lateral Incisor	231 (10)	289 (10)	127 (11)	*647 (10)*
	Incisor Totals	*435 (19)*	*526 (19)*	*231 (20)*	*1192 (19)*
	Canine Totals	*282 (12)*	*358 (13)*	*168 (14)*	*808 (13)*
	Premolar 1	299 (13)	360 (13)	162 (14)	*821 (13)*
	Premolar 2	289 (13)	360 (13)	152 (13)	*801 (13)*
	Premolar Totals	*588 (26)*	*720 (26)*	*314 (27)*	*1622 (26)*
	Molar 1	355 (16)	436 (15)	169 (14)	*960 (15)*
	Molar 2	350 (15)	437 (15)	175 (15)	*962 (15)*
	Molar 3	272 (12)	344 (12)	111 (10)	*727 (12)*
	Molar Totals	*977 (43)*	*1217 (43)*	*455 (39)*	*2649 (42)*
	Total Present	*2282 (36)*	*2821 (45)*	*1168 (19)*	***6271 (100)***

†Percentages for each case of sex calculated against total present teeth for that case. Percentages for Totals of each tooth type calculated against overall total present teeth (n=6271).

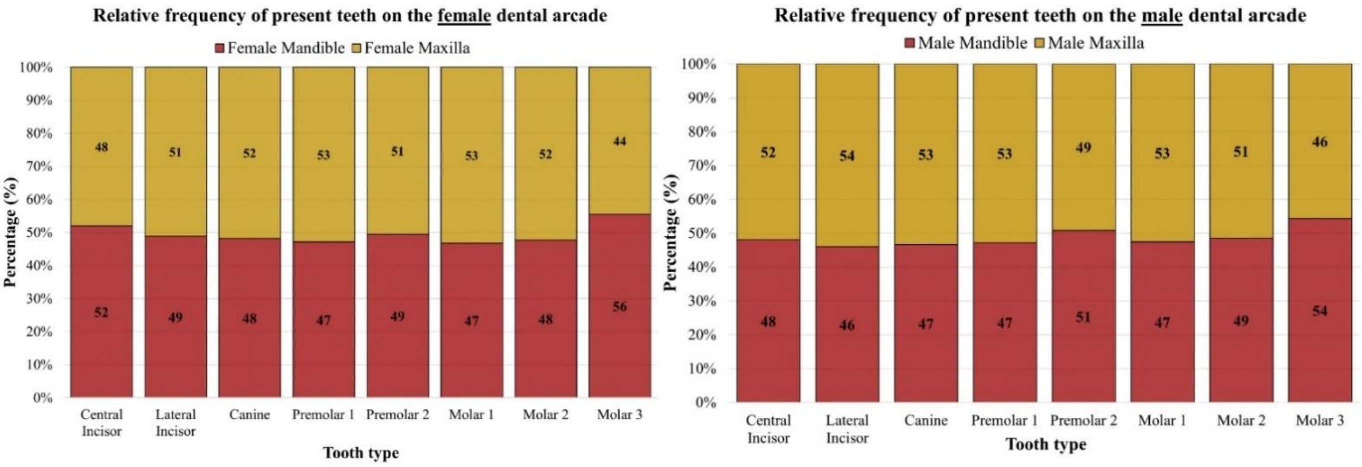


Figure 4.6: Female and male relative frequency expressed in percentage of present teeth on maxillae and mandibles.

Table 4.4: Distribution of present teeth for each tooth type against age-at-death. Relative frequencies were calculated against the total present teeth to demonstrate relative distribution for the total sample.

		Age-at-death						
		Young adult	**Young/ Middle adult**	**Middle adult**	**Middle/ Old adult**	**Old adult**	**Indeterminate**	***Totals***
Variables		***n (%)***	***n (%)***	***n (%)***	***n (%)***	***n (%)***	***n (%)***	***n (%)***
Tooth type†	Central Incisor	14 (7)	108 (8)	64 (9)	73 (8)	15 (11)	271 (10)	*545 (9)*
	Lateral Incisor	17 (8)	141 (10)	69 (10)	90 (9)	15 (11)	315 (11)	*647 (10)*
	Incisor Totals	*31 (15)*	*249 (18)*	*133 (18)*	*163 (17)*	*30 (21)*	*586 (21)*	*1192 (19)*
	Canine Totals	*24 (12)*	*174 (12)*	*89 (12)*	*124 (13)*	*14 (10)*	*383 (13)*	*808 (13)*
	Premolar 1	24 (12)	183 (13)	95 (13)	116 (12)	24 (17)	379 (13)	*821 (13)*
	Premolar 2	24 (12)	183 (13)	96 (13)	112 (12)	17 (12)	369 (13)	*801 (13)*
	Premolar Totals	*48 (23)*	*366 (26)*	*191 (26)*	*228 (24)*	*41 (29)*	*748 (26)*	*1622 (26)*
	Molar 1	36 (18)	224 (16)	114 (16)	155 (16)	17 (12)	414 (15)	*960 (15)*
	Molar 2	36 (18)	219 (16)	112 (16)	158 (17)	23 (16)	414 (15)	*962 (15)*
	Molar 3	30 (15)	176 (13)	83 (11)	120 (13)	17 (12)	301 (11)	*727 (12)*
	Molar Totals	*102 (50)*	*619 (44)*	*309 (43)*	*433 (46)*	*57 (40)*	*1129 (40)*	*2649 (42)*
	Total Present	*205 (3)*	*1408 (22)*	*722 (12)*	*948 (15)*	*142 (2)*	*2846 (45)*	***6271 (100)***

†Percentages for each case of age-at-death calculated against total present teeth for that case. Percentages for Totals of each tooth type calculated against overall total present teeth (n=6271).

Table 4.5 presents cross-tabulated data related to the age and sex distribution of the sample. When excluding indeterminate/unobservable factors, females had the highest representation for young adults (64%; 7/11) followed by old adults (57%; 4/7), middle adults (56%; 22/39), young/middle adults (42%; 29/69), and middle/old adults (29%; 15/51). Small sample sizes may inflate relative frequencies for young and old adults. In males, the highest representation was in middle/old adults (71%; 36/51), young/middle adults (58%; 40/69), middle adults (44%; 17/39), old adults (43%; 3/7), and young adults (36%; 4/11).

Table 4.5: Cross-tabulated distributions of present teeth for sex and age-at-death for present individuals and teeth.

Age and Sex			Age categories							
			Young Adult	Young/ Middle Adult	Middle Adult	Middle/ Old Adult	Old Adult	Totals†	Indeterminate/Unobservable	Totals
Number of individuals	Female	n	7	29	22	15	4	77	54	131
		%	64	42	56	29	57	44	50	46
	Male	n	4	40	17	36	3	100	53	153
		%	36	58	44	71	43	56	50	54
	Totals†	**n**	**11**	**69**	**39**	**51**	**7**	**177**	**107**	**284**
		%	**100**	**97**	**98**	**88**	**78**	**94**	**59**	**77**
	Indeterminate/ unobservable	n	0	2	1	7	2	12	73	85
		%	0	3	3	12	22	6	41	23
	Totals‡	**n**	**11**	**71**	**40**	**58**	**9**	**189**	**180**	**369**
		%	**3**	**19**	**11**	**16**	**2**	**51**	**49**	**100**
Number of teeth*	Female	n	135/224	535/928	377/704	233/480	55/128	1335/2464	947/1728	2282/4192
		%	60	58	54	49	43	54	55	54
	Male	n	70/128	836/1280	318/544	618/1152	45/96	1887/3200	934/1696	2821/4896
		%	55	65	58	54	47	59	55	58
	Indeterminate/ unobservable	n	0/0	37/64	27/32	97/224	42/64	203/384	965/2336	1168/2720
		%	0	58	84	43	66	53	41	43
	Totals	**n**	**205/352**	**1408/2272**	**722/1280**	**948/1856**	**142/288**	**3425/6048**	**2846/5760**	**6271/11808**
		%	**58**	**62**	**56**	**51**	**49**	**57**	**49**	**53**

†Totals include total of sexed and aged individuals and excludes indeterminate/unobservable categories.
‡Totals are calculated against total inclusive of sexed, aged, and indeterminate/unobservable individuals.
*Number of present teeth/number of present teeth plus teeth lost antemortem, postmortem, missing and broken within its age and sex category.

4.1.2.2 Spatial and temporal distributions

Data related to the spatial distribution of the sample are presented in relative frequency and exact frequency per tooth type in Figures 4.2 and 4.4 and below in Table 4.6, where 98% (363/369) of individuals had a specific provenance with 99% (6200/6271) of teeth. Six individuals, or 2%, had unknown provenances representing 1% (71/6271) of teeth. Overall, the coastal region represented 87% (314/363) of individuals, and 13% (49/363) of individuals had a provenance from inland areas. Of teeth present, 87% (5376/6200) of all present teeth were from coastal individuals and 13% (824/6200) from inland individuals.

Table 4.6: Distribution of present teeth for each tooth type against spatial regions. Relative frequencies calculated against the total present teeth, demonstrating relative distribution for the total sample.

		Frequency of present teeth for spatial			
		Coastal	Inland	Unknown	*Totals*
Variables		*n (%)*	*n (%)*	*n (%)*	*n (%)*
Tooth type†	Central Incisor	479 (9)	60 (7)	6 (8)	*545 (9)*
	Lateral Incisor	573 (11)	68 (8)	6 (8)	*647 (10)*
	Incisor Totals	*1052 (20)*	*128 (15)*	*12 (17)*	***1192 (19)***
	Canine Totals	*697 (13)*	*101 (12)*	*10 (14)*	***808 (13)***
	Premolar 1	706 (13)	104 (13)	11 (15)	*821 (13)*
	Premolar 2	695 (13)	99 (12)	7 (10)	*801 (13)*
	Premolar Totals	*1401 (26)*	*203 (24)*	*18 (25)*	***1622 (26)***
	Molar 1	811 (15)	139 (17)	10 (14)	*960 (15)*
	Molar 2	806 (15)	144 (17)	12 (17)	*962 (15)*
	Molar 3	604 (11)	114 (14)	9 (13)	*727 (12)*
	Molar Totals	*2221 (41)*	*397 (48)*	*31 (44)*	***2649 (42)***
	Total Present	*5371 (86)*	*829 (13)*	*71 (1)*	***6271 (100)***

†Percentages for each spatial case for tooth type calculated against total present teeth for that case.
Percentages for Totals of each tooth type calculated against overall total present teeth (n=6271).

Data related to temporal distributions of pre/post-2000 BP and Holocene divisions of the sample were presented in exact frequency and relative frequency, respectively, per tooth type in Figures 4.3 and 4.5 and below in Tables 4.7 and 4.8. For both temporal categories, 82% (301/269) had a date with 83% (5177/6271) of teeth, and 18% (68/369) had unknown dates possessing 17% (1094/6271) of teeth. For pre/post-2000 BP, 62% (187/301) of total individuals were from pre-2000BP and 38% (114/301) from post-2000BP. Of all teeth present, 60% (3091/5177) were from pre-2000, and 40% (2086/5177) were from post-2000.

Table 4.7: Distribution of present teeth for each tooth type against pre/post-2000 BP. Relative frequencies calculated against the total present teeth, demonstrating relative distribution for the total sample.

		Frequency of present teeth for pre-/post-2000 BP			
		Pre-2000	Post-2000	Unknown	*Totals*
Variables		*n (%)*	*n (%)*	*n (%)*	*n (%)*
Tooth type†	Central Incisor	281 (9)	162 (8)	102 (9)	*545 (9)*
	Lateral Incisor	323 (10)	213 (10)	111 (10)	*647 (10)*
	Incisor Totals	*604 (20)*	*375 (18)*	*213 (19)*	***1192 (19)***
	Canine Totals	*405 (13)*	*264 (13)*	*139 (13)*	***808 (13)***
	Premolar 1	407 (13)	266 (13)	148 (14)	*821 (13)*
	Premolar 2	405 (13)	260 (12)	136 (12)	*801 (13)*
	Premolar Totals	*812 (26)*	*526 (25)*	*284 (26)*	***1622 (26)***
	Molar 1	470 (15)	321 (15)	169 (15)	*960 (15)*
	Molar 2	468 (15)	329 (16)	165 (15)	*962 (15)*
	Molar 3	332 (11)	271 (13)	124 (11)	*727 (12)*
	Molar Totals	*1270 (41)*	*921 (44)*	*458 (42)*	***2649 (42)***
	Total Present	*3091 (49)*	*2086 (33)*	*1094 (17)*	***6271 (100)***

†Percentages for each pre-/post-2000 BP case for tooth type calculated against total present teeth for that case.
Percentages for Totals of each tooth type calculated against overall total present teeth (n=6271).

Regarding Holocene divisions, 17% (50/301) of total individuals were from the earlier Holocene, 46% (137/301) were from the middle Holocene, and 38% (114/301) were from the later Holocene. Therefore, most individuals dated to the middle Holocene and the least number of individuals dated to the earlier Holocene. Of all teeth present, 14% (735/5177) were from earlier Holocene individuals, 46% (2356/5177) were from the middle Holocene, and 40% (2086/5177) were from the later Holocene.

Table 4.8: Distribution of present teeth for each tooth type against pre/post-2000 BP. Relative frequencies calculated against total present teeth demonstrating relative distribution for the total sample.

		Frequency of present teeth for Holocene divisions				
		Earlier Holocene	**Middle Holocene**	**Later Holocene**	**Unknown**	***Totals***
Variables		***n (%)***	***n (%)***	***n (%)***	***n (%)***	***n (%)***
Tooth type†	Central Incisor	66 (9)	215 (9)	162 (8)	102 (9)	*545 (9)*
	Lateral Incisor	83 (11)	240 (10)	213 (10)	111 (10)	*647 (10)*
	Incisor Totals	*149 (20)*	*455 (19)*	*375 (18)*	*213 (19)*	*1192 (19)*
	Canine Totals	*101 (14)*	*304 (13)*	*264 (13)*	*139 (13)*	*808 (13)*
	Premolar 1	99 (13)	308 (13)	266 (13)	148 (14)	*821 (13)*
	Premolar 2	97 (13)	308 (13)	260 (12)	136 (12)	*801 (13)*
	Premolar Totals	*196 (27)*	*616 (26)*	*526 (25)*	*284 (26)*	*1622 (26)*
	Molar 1	103 (14)	367 (16)	321 (15)	169 (15)	*960 (15)*
	Molar 2	106 (14)	362 (15)	329 (16)	165 (15)	*962 (15)*
	Molar 3	80 (11)	252 (11)	271 (13)	124 (11)	*727 (12)*
	Molar Totals	*289 (39)*	*981 (42)*	*921 (44)*	*458 (42)*	*2649 (42)*
	Total Present	*735 (12)*	*2356 (38)*	*2086 (33)*	*1094 (17)*	***6271 (100)***

†Percentages for each Holocene division for tooth type calculated against total present teeth for that case. Percentages for Totals of each tooth type calculated against overall total present teeth (n=6271).

Cross-tabulated spatial and temporal distributions are presented below in Table 4.9. Coastal remains were more prevalent in pre-2000 BP (97%, 180/186), and when further divided, the middle Holocene (98%, 133/136), followed by 73% (82/112) in the later Holocene. Of inland individuals, the vast majority dated to post-2000 BP or the later Holocene (27%, 30/112). Very few inland individuals dated to pre-2000 BP; the earlier and middle Holocene included three individuals.

Table 4.9: Cross-tabulated spatial and temporal data for present individuals and teeth.

Temporal and Spatial			Pre-/Post-2000 BP				Holocene divisions					
			Pre-2000 BP	Post-2000 BP	Totals†	Unknown	Earlier Holocene	Middle Holocene	Later Holocene	Totals†	Unknown	Totals*
Number of individuals	Coastal	n	180	82	262	52	47	133	82	262	52	314
		%	97	73	88	80	94	98	73	88	80	**85**
	Inland	n	6	30	36	13	3	3	30	36	13	49
		%	3	27	12	20	6	2	27	12	20	**13**
	Totals†	**n**	**186**	**112**	**298**	**65**	**50**	**136**	**112**	**298**	**65**	**363**
		%	**99**	**99**	**99**	**94**	**100**	**99**	**99**	**99**	**94**	**98**
	Unknown	n	1	1	2	4	0	1	1	2	4	6
		%	0	0	1	1	0	0	0	1	1	**2**
	Totals**	**n**	**187**	**113**	**300**	**69**	**50**	**137**	**113**	**300**	**69**	**369**
		%	**51**	**31**	**81**	**19**	**14**	**37**	**31**	**81**	**19**	**100**
Number of teeth‡	Coastal	n	2949/5760	1532/2624	**4481/8384**	895/1664	677/1504	2272/4256	1532/2624	**4481/8384**	895/1664	5376/10048
		%	51	58	**53**	54	45	53	58	**53**	54	**54**
	Inland	n	126/192	549/960	**675/1152**	149/416	58/96	68/96	549/960	**675/1152**	149/416	824/1568
		%	66	57	**59**	36	60	71	57	**59**	36	**53**
	Unknown	n	16/32	5/32	**21/64**	50/128	0/0	16/32	5/32	**21/64**	50/128	71/192
		%	50	16	**33**	39	0	50	16	**33**	39	**77**
	Totals	**n**	**3091/5984**	**2086/3616**	**5177/9600**	**1094/2208**	**735/1600**	**2356/4384**	**2086/3616**	**5177/9600**	**1094/2208**	**6271/11808**
		%	**52**	**58**	**54**	**50**	**46**	**54**	**58**	**54**	**50**	**53**

† Totals exclude indeterminate/unobservable categories and are calculated against dated individuals.
‡ Number of present teeth/number of present teeth plus teeth lost antemortem, postmortem, missing and broken within its age and sex category.
* Of either pre-/post-2000 BP or Holocene divisions, as both categories represent the same totals.
** Totals are calculated against total inclusive of sexed, aged, and indeterminate/unobservable individuals

4.2 Discussion

A description of sample distribution, including individual frequencies and dental inventory, was presented earlier in this chapter. Several facets of the sample distribution require further consideration; the subsequent sections elaborate upon the presented results and certain sample biases illustrated in this chapter.

4.2.1 Method repeatability

As most age and sex data were acquired from a project by a 2021 Master of Philosophy student, inter-reliability assessments aimed to reduce limitations when using qualitative methodologies such as observer subjectivity, trait evaluation inconsistencies, and a dependence on an observer's prior results (Bruzek, 2002). Despite strong agreements of 0.92 for age estimation and 0.94 for sex estimation, sAHGH individuals are known for their small stature (Pfeiffer & Harrington, 2011) and high activity levels (Churchill & Morris, 1998), both potentially resulting in underestimated age estimations (Merritt, 2015; Pfeiffer et al., 2019; Gibbon & Davies, 2020) and diminished sexual dimorphic traits of the crania (Gibbon & Davies, 2020; Malek, 2022). Therefore, reliability assessments permit the acknowledgement of these aspects.

4.2.2 Sample representation

This sample had good statistical power of a minimum of 15 individuals per assessed variable at a 95% confidence interval for 80% power when the effect is large (h = 0.8) and a good number of teeth present (n = 6271), despite a moderate number of teeth lost antemortem (n = 208), and a considerable number lost postmortem (n = 5329). The sample demonstrated bilaterally symmetrical distribution between maxillary and mandibular jaws for present teeth. A predictable development of wear, a major variable of this thesis, is a result of normal dental occlusion, which ideally requires symmetrical occlusal contact of all present teeth (Smith, 1984; Watanabe, Hattori & Satoh, 2005) and the presence of anomalous examples would contribute to inferences on interindividual variation as demonstrated by dental wear or dental pathology (Kaidonis, 2008). Absent teeth also exhibited bilaterally symmetrical distribution; only AMTL exhibited a discrepancy between jaws where tooth loss was most apparent in mandibles (61%, 127/208) than in maxillae (39%, 81/208), although Chapter 6 elaborates on this aspect.

To apply the methods in this thesis on dentition, there would technically be no minimum requirement for the number of teeth, however, the minimum number of teeth was determined to account for accuracy in overall dental wear quantity scores and individual score representation. A wear score based on an individual tooth would be unreliable in representing the whole dentition, namely for calculating an average wear score to provide a broad overview of general wear score patterns. Where an average only requires two values to be calculated, wear stages may vary and including more teeth would improve the accuracy of this calculation. Therefore, a minimum of three teeth was deemed to better represent the average wear per individual over utilising only two teeth, whilst also considering the limitations for this sample relative to expectations of poor-preservation and limited remains. Of individuals with less than three teeth, the preservation ranged between poor, fair, or good, but there was a relevance of descriptions as 'poor' and fragmentary. Although within this subgroup of individuals with ≤3 teeth, some individuals demonstrated good preservation but excessive handling of the remains over the years may have affected the presence of material. For example, an individual was considered of 'good' preservation, however, there were discrepancies between how many teeth were present according to the individual's biological report from the repository, indicating ‘high presence of teeth’ but only three teeth were present.

The sample included 369 individuals, which was also sufficient to meet statistical power, and includes the most individuals to date compared to published studies on precontact sAHGH dental wear and oral pathology (Drennan, 1929; Morris, Thackeray & Thackeray, 1987; Sealy & van der Merwe, 1988; Patrick, 1989; Jerardino et al., 1992; Sealy et al., 1992; Van Reenen, 1992; Constant & Grine, 2001; Gibbon & Davies, 2020; Pfeiffer et al., 2020). Although past large-scale projects also included large sample sizes on macroscopic analyses for sAHGH dentition, such as those by Black (2014) with 487 individuals and Morris (1984, 1992a) with 341 individuals, these studies either had alternative primary aims (e.g., dental traits) or prioritised sAHGH remains from contact periods. The sample size in this study is also in line with sample sizes in some relevant global HGH studies; for example, Littleton (2017) included 115 individuals, Costa (1980) included 246, and Deter (2009) included 306 individuals. Therefore, this study is the first systematic assessment of a large study sample of sAHGH remains that collectively assess oral health and dental wear, including quantity and direction.

4.2.3 Sex and age estimation

The distribution of sex was similar between females and males (46%, 131/284; 54%, 153/284, respectively), whereas 23% (85/369) were unobservable in the whole sample. The moderate number of unobservable individuals was due to poor preservation or reconstruction techniques that negatively affected an accurate estimation of sex. Although this study utilised multiple techniques, the pelvis received priority as it is considered a reliable indicator of sex (Inskip et al., 2019) due to morphological differentiation related to childbirth (Klales, Ousley & Vollner, 2012). Unfortunately, the pelvis is reportedly recovered in 66% of archaeological excavations (Waldron, 1987) and accurately estimating sex is only possible when the pelvic element is complete. Therefore, assessing cranial traits is typically a subsequent priority, where Walker (2008) reported overall sex-estimation accuracies of 89% on European American, African American, English, and precontact Native American populations, when combining results from all five cranial traits as outlined by Buikstra and Ubelaker (1994). Krüger and colleagues (2015) reported on modified population-specific accuracies using logistic regressions that increased accuracies to between 84 and 93% for sex-estimation on contemporary ‘black’ and ‘white’ South Africans. Combining methodologies provides the most effective sex estimate; for example, Inskip and colleagues (2019) reported an accuracy rate of over 97% when utilising combined pelvic and cranial macroscopic traits. Their reported results outperformed accuracy rates when using either the os coxae (>95%) or the skull (>90%), although individual elements also demonstrated excellent accuracy. Utilising multiple methodologies allowed for the possibility of acquiring an accurate sex estimate on most individuals despite confounding factors affecting visibility or present skeletal elements. Where some skeletal elements were either damaged or incomplete, past studies were referenced that had already reported sex estimates on particular individuals (Hausman, 1980; Pfeiffer & Sealy, 2006; Stynder, Ackermann & Sealy, 2007; L'Abbé, Loots & Keough, 2008; Sealy, 2010; Black, 2014; Campbell, 2019), likely representing periods where the skeletal remains of an individual were in better condition.

For age-at-death, only half of the sample (51%, 189/369) had an estimate, and young/middle-aged adults dominated the distribution, a transitory category that included individuals with a vast age range from compiling multiple ageing techniques. Buckberry (2015) extensively discussed that further research was required to standardise adult-ageing in bioarchaeology to determine unbiased but combined age estimates. Therefore, the implementation of transitory categories (e.g., young/middle or middle/old adults) was necessary to avoid using mean ages, which would inaccurately assume the age of an individual in a sample whose distribution reflects sporadic age-at-death structures (Buckberry, 2015) due to a wide temporal distribution (<11,700 years) and varying levels of archaeological preservation. Additional to transitory categories, old-aged adults represented the fewest individuals (5%, 9/189) with an age, and fewest present teeth (4%, 142/3425) from those with age-estimates. Old-aged adults typically exhibit increased rates of AMTL (Lukacs, 2007), which correlates with increased rates of dental pathology, dental wear, and root resorption (Merbs, 1968; Larsen, 1995; Lukacs, 2007). The small sample size in this study for individuals and teeth on old-aged adults was more likely impacted by small sample assemblages, as young adults—who represented the second-fewest individuals in an age group (6%, 11/189)—demonstrated 6% (205/3425) of teeth present. From this, one can interpret that sample biases for age categories were due to preservation issues or ambiguous morphological characteristics that otherwise grouped the individuals into one of the transitory categories.

In addition to sample bias, there is a lack of specific methods for sex and age estimation designed for sAHGH remains, as elaborated upon by Malek (2022), and due to the smaller mass, dental and body size of sAHGH individuals, the use of population-specific metric techniques was deemed unsuitable for this study. Non-metric methods were further beneficial as they may be conducted on fragmented remains (Klales, Ousley & Vollner, 2012). As aforementioned, sAHGH morphology and activity can reflect underestimated age estimations (Pfeiffer & Harrington, 2011; Merritt, 2015; Pfeiffer et al., 2019). Therefore, sternal rib ends were prioritised as a reliable technique because the rib does not remodel or modify from physical activity (Oettlé & Steyn, 2000). Rather, the sternal ends of the ribs remodel at a regular rate due to age degeneration, bar from deteriorating pathology (e.g., tuberculosis, DISH) (Oettlé & Steyn, 2000; Mann & Hunt, 2013). It is worth noting that İşcan and Loth (1986a,b) designed their methods from a sample of 'white' males and females. Therefore, this dissertation also used revised standards published by Oettlé and Steyn (2000) to mitigate the lack of population-specific methods. The authors reliably replicated that of İşcan and Loth (1986a,b), albeit on 'black' South African males and females.

In line with these considerations, third molar eruption has also demonstrated population-specific variation, as reported in multiple studies for African individuals (Oziegbe, Esan & Oyedele, 2014; Cavrić et al., 2016; Esan & Schepartz, 2018). The London Atlas (AlQahtani, Hector & Liversidge, 2010, 2014) is a commonly used resource for dental ageing through eruption; however, the samples used in their study were from Portugal, the Netherlands, Canada, France, and living children with Bangladeshi and British origin (AlQahtani, Hector & Liversidge, 2014; Esan & Schepartz, 2018). Instead, the WITS Atlas (Esan and Schepartz, 2018) examined southern African children and reported earlier eruption times. Between these two atlases, the third molars emerge at a difference of four years, erupting at 15.5 years in the WITS atlas and 18 years in the London Atlas. Methodological adjustments in this study considered the variation in third molar eruption time, where sAHGH eruption may differ from contemporary expectations. Nevertheless, until researchers publish population-specific standards on these remains, the WITS Atlas was the primary source referenced for southern African remains and used alongside other ageing techniques.

4.2.4 Spatial regions

A considerable discrepancy in demographic categories was prevalent for spatial regions, where 87% (314/363) of provenanced individuals were coastal, and 13% (49/363) were inland. There were six remaining individuals with unknown provenance; however, the archival record for these remains indicated they were sAHGH individuals, although their exact archaeological provenance was unavailable at the time of data collection.

Most sAHGH bioarchaeological studies have acknowledged this bias for coastal distribution and have also relied on coastal remains (Morris, Thackeray & Thackeray, 1987; Sealy & van der Merwe, 1988; Sealy et al., 1992; Sealy & Pfeiffer, 2000; Stock & Pfeiffer, 2004; Pfeiffer & Sealy, 2006; Sealy, 2006; Pfeiffer, 2007; Kurki et al., 2010; Sealy, 2010; Pfeiffer & Harrington, 2011; Black, 2014; Orton et al., 2015; Pfeiffer et al., 2019; Gibbon &

Davies, 2020; Malek, 2022), where some exceptions incorporated remains from inland contexts (Drennan, 1929; Van Reenen, 1964, 1992; Morris, 1992a; Sealy et al., 1992; Black, 2014; Irish et al., 2014). However, samples from studies with inland provenances tend to be small, analysed from a site-specific perspective, or included criteria such as remains from contact periods. Contact was made with repositories in other southern African nations, including Botswana and Zambia, to reduce this bias. Unfortunately, these repositories did not meet all inclusion criteria; otherwise, the repositories had too few individuals to justify international travel, which the COVID-19 pandemic greatly hindered.

Representation of sAHGH archaeological remains varies between spatial regions for numerous reasons. When further divided into southern African biomes (Rutherford, Mucina & Powrie, 2006), one explanation can include shortages of archaeologists, such as in the savanna biome compared to coastal regions. Otherwise, discrepancies can also be due to sAHGH clustering around river systems, as demonstrated in the Nama-Karoo biome or coastal fynbos and forest rock shelters, and a resultant lack of excavation efforts in the surrounding landscape. Mainly, however, archaeological visibility has been the most significant contributor to preferential excavation along the coast from wind-blown dunes exposing buried individuals and otherwise due to rapid urban development, chiefly along the coast, which has led to large-scale earth movement (Morris, 1992b; Sealy, 2010). Skeletal preservation is contingent on the region an individual was buried, where ultimately, the odds of more individuals with good preservation increase with a larger sample size. For example, the skeletal matrix tends to favour calcareous marine sands resulting in better preservation of coastal remains (Sealy, 2010). Yet, it is still possible for remains along the coast to demonstrate leached and brittle bones, accredited to isolated regions with increased soil acidity (Morris, Thackeray & Thackeray, 1987).

Lander and Russell (2018) revisited southern African archaeological literature and expressed the need for sAHGH data from the interior of southern Africa. Other relevant inland nations to South Africa included Botswana, Mozambique, and Angola, which have all demonstrated extensive archaeological evidence for sAHGH activity (Mazel, 1996; Bollong, Sampson & Smith, 1997; Sadr & Sampson, 1999; Sampson, 2010; Ginter, 2011; Orton et al., 2013; Sadr, 2015; Lander & Russell, 2020). In-land contexts have shown interrupted occupation cycles, such as the Drakensberg area showing sporadic signs of occupation contingent on the climatic period (Lewis, 2008). Whereas coastal regions and the Cape Fold Belt saw frequent occupation throughout the Holocene as the abundance of food along the coast made these regions an attractive location for resource security (Pfeiffer & Sealy 2006). However, Lewis (2008) and several other authors have also discussed coastal population density fluctuating with changing climate and sea levels throughout the Holocene (Deacon, 1974; Mitchell, 2002; Stock & Pfeiffer, 2004; Pfeiffer et al., 2019); in addition to an overall increasing population density as prevalent along the coast during the middle Holocene (Sealy & Pfeiffer, 2000), and the apparent increase in population density within the interior of southern Africa during the later Holocene (Lewis, 2008). This thesis included six inland individuals dating to pre-2000 BP, compared to 30 inland individuals in post-2000 BP, which indicates that the sample distribution was still somewhat skewed between periods for inland individuals. Additionally, past studies have already discussed the lack of remains from earlier in the Holocene and Pleistocene (Stynder, 2006; Grine, 2016), likely due to time-related taphonomic processes (Morris, 1992a; Stynder, 2006). At this time, it may be concluded that biases in spatial distribution are due to a lack of data on skeletal remains from the interior of southern Africa.

4.2.5 Temporal classifications

Temporal observations were segmented into two broad classifications of pre/post-2000 BP and Holocene divisions. Pre-2000 BP included 62% (187/301) of dated individuals, further divided into the earlier Holocene (17%, 50/301) and the middle Holocene (46%, 137/301), followed by post-2000 BP with 38% (114/301), further divided into the later Holocene (38%, 114/301). In the whole sample, 18% (68/369) of individuals had unknown exact dates, but the archival record reported them as precontact remains. Pre-2000 BP spanned a much broader timeframe than post-2000 BP, and the earlier Holocene spanned more time than the other two Holocene divisions. This was due to archaeological sAHGH remains from before 4000 BP being relatively rare (Stynder, 2006), which was prevalent in the sample distribution from this study.

Shifts in economies and practices occurred around 2000 BP, brought upon by archaeological evidence of changing industrial complexes and faunal evidence of livestock, resultantly becoming a turning point from hunting-gathering to hunting/gathering-herding (Deacon et al., 1978; Sadr, 2003, 2004, 2008a,b; Stynder, 2006; Ginter, 2011). Some individuals had radiocarbon dates of exactly 2000 BP yet were ‘pre-2000 BP’ in this study. Transitions into new lifeways occur gradually (Ginter, 2011); therefore, there was an expectation that elements of a pre-2000 BP lifestyle were still prevalent just beyond 2000 BP (Loftus, Mitchell & Ramsey, 2019). Moreover, I regarded adult individuals whose C14 dates represent a marginal date at which they passed. These individuals would have likely first lived through a segment of pre-2000 BP, possibly passing away as adults in post-2000 BP during the gradual transition to pastoralism. These combined aspects supported the classification of a few individuals with C14 dates of ‘exactly’ 2000 BP as pre-2000 BP individuals.

Holocene divisions of earlier Holocene (11,700 – 4000 BP), middle Holocene (4000 – 2000 BP), and later Holocene (<2000 BP) were used in this research, as similarly presented by Stynder (2006). Theoretically, a cut-off date of 4200 BP for the earlier to middle Holocene would align with the sub-epochs as determined by the International Commission on Stratigraphy (ICS). Notably, southern Africa from 4000 BP was accompanied by changing environmental conditions in the form of lower temperatures, increased rainfall, evolving fauna, and a dramatic increase in sAHGH population numbers (Pfeiffer & Sealy, 2006; Stynder, 2006; Ginter, 2011). This suggests that the landscape and people of southern Africa were transforming at an internal rate from 4000 BP, which was relevant to drawing local biocultural inferences. This research also considered Marine Reservoir Corrections (MRC) as a recent development in the literature (Dewar et al., 2012; Loftus, Sealy & Lee-Thorp, 2016; Loftus, Mitchell & Ramsey, 2019); however, marine absolute dating sources yield a “reservoir” effect which considerably complicates determining precise age ranges. Consequently, the calibration of C14 dates for individuals with a high amount of marine food consumption can present a ~200 year margin because of the uncertainty in the exact amount of seafood that sAHGH individuals had consumed (Dewar et al., 2012; Lewis & Sealy, 2018; Loftus, Mitchell & Ramsey, 2019; Pfeiffer et al., 2020; JC Sealy 2021, personal communication, 12 November). Therefore, Holocene divisions were determined as presented in this study, considering past literature has used an archaeological chronology of 4000 BP as a temporal marker within the southern African Holocene (Stynder, 2006; Stynder, Ackermann & Sealy, 2007; Ginter, 2011), along with the abovementioned confounding factors with seafood consumption affecting MRC calibrated radiocarbon dates.

Chapter summary

In this chapter, I presented age and sex estimation reliability results and outlined the sample distribution, indicating that the study sample included enough individuals and teeth to draw valid inferences for the primary aim of a systematic assessment of sAHGH teeth. Although there was an expectation for sampling biases within demographic classifications, this chapter further explained the limitations. This chapter also highlighted gaps in the archaeological record through the presence of ‘unknown’ classifications. Notably, future research should focus on creating population-specific sex and ageing methods, along with efforts to radiocarbon date additional individuals and uncover remains from the interior of southern Africa. In the subsequent chapter, I elaborate on the dental wear characteristics of this sample.

CHAPTER 5: DENTAL MACROWEAR & NON-MASTICATORY WEAR RESULTS & DISCUSSION

Intra and inter-observer tests were conducted for dental wear quantity and direction using the Brabant index, and the results of the assessments are detailed in this chapter. Weak reliability in initial tests warranted the optimisation of the index, and this chapter presents the improved version, inclusive of a visual guide and multicuspid scores. A discussion follows on method repeatability and observer subjectivity for qualitative methods and the need for reassessments to confirm method validity on different populations. Subsequently, dental macrowear quantity and direction, and non-masticatory wear results are presented. Discussions pertaining to dental macrowear and non-masticatory wear follow, concluding with the discussion of dental macrowear against demographics.

Dental macrowear for quantity and direction were recorded on all teeth without the effect of postmortem processes or obstructive pathological conditions. Per the adaptation of the visual and modified guide to the Brabant index, all anterior teeth were observed for a single dental wear score, whereas posterior teeth were observed for two scores (buccal and lingual).

5.1 Method repeatability

Two separate inter-observers with varying levels of experience with teeth, observers 1 and 2 (O1 and O2), assessed dental wear reliability. Dental wear quantity wKappa scores improved for the intra-observer (author) and observer 2 (O2) following method modification, with an improved intra-observer result of 0.94 and an O2 inter-observer score of 0.89 (Table 5.1). Dental wear direction wKappa results were similar, with an improved intra-observer score of 0.99 and an O2 inter-observer score of 0.82. Notably, the modified macrowear method improved the accuracy and reliability of scoring for the more experienced observer (O2), although did not improve the accuracy for an inexperienced observer (O1).

Table 5.1: Intra- and inter-observer weighted Kappa and Cohen's kappa results for dental wear quantity and direction.

Test	Observer	Assessment	wKappa	95%CI†
		Dental wear quantity		
Intra-observer	Author	Assessment 1	0.94	0.92 – 0.95
		Assessment 2	0.99	0.98 – 0.99
Inter-observer	Observer 1	Assessment 1	0.86	0.84 – 0.88
		Assessment 2	0.80	0.78 – 0.82
	Observer 2	Assessment 1	0.89	0.88 – 0.91
		Assessment 2	0.96	0.93 – 0.97
		Dental wear direction		
Test	**Observer**	**Assessment**	**wKappa**	**95%CI†**
Intra-observer	Author	Assessment 1	0.87	0.81 – 0.91
		Assessment 2	0.99	0.97 – 0.99
Inter-observer	Observer 1	Assessment 1	0.26	0.19 – 0.33
		Assessment 2	0.23	0.20 – 0.27
	Observer 2	Assessment 1	0.81	0.69 – 0.89
		Assessment 2	0.82	0.78 – 0.85

†95% CI is the confidence interval at 95%, demonstrating the lower and upper CI range.

5.1.1 Brabant index adjustments

Initial discordant results from intra- and inter-observer assessments indicated weaker repeatability of dental wear methodologies employed using the Brabant index. Although dental wear quantity would have benefited from some improvement, the responses relative to dental wear direction were of greater concern due to subjectivity. Due to the integral role of macroscopically examining dental wear, adjustments to the methods were deemed necessary. Thus, I modified the Brabant index by designing and creating a visual guide to improve an observer's ability to identify the differences between each score category (Figure 5.1).

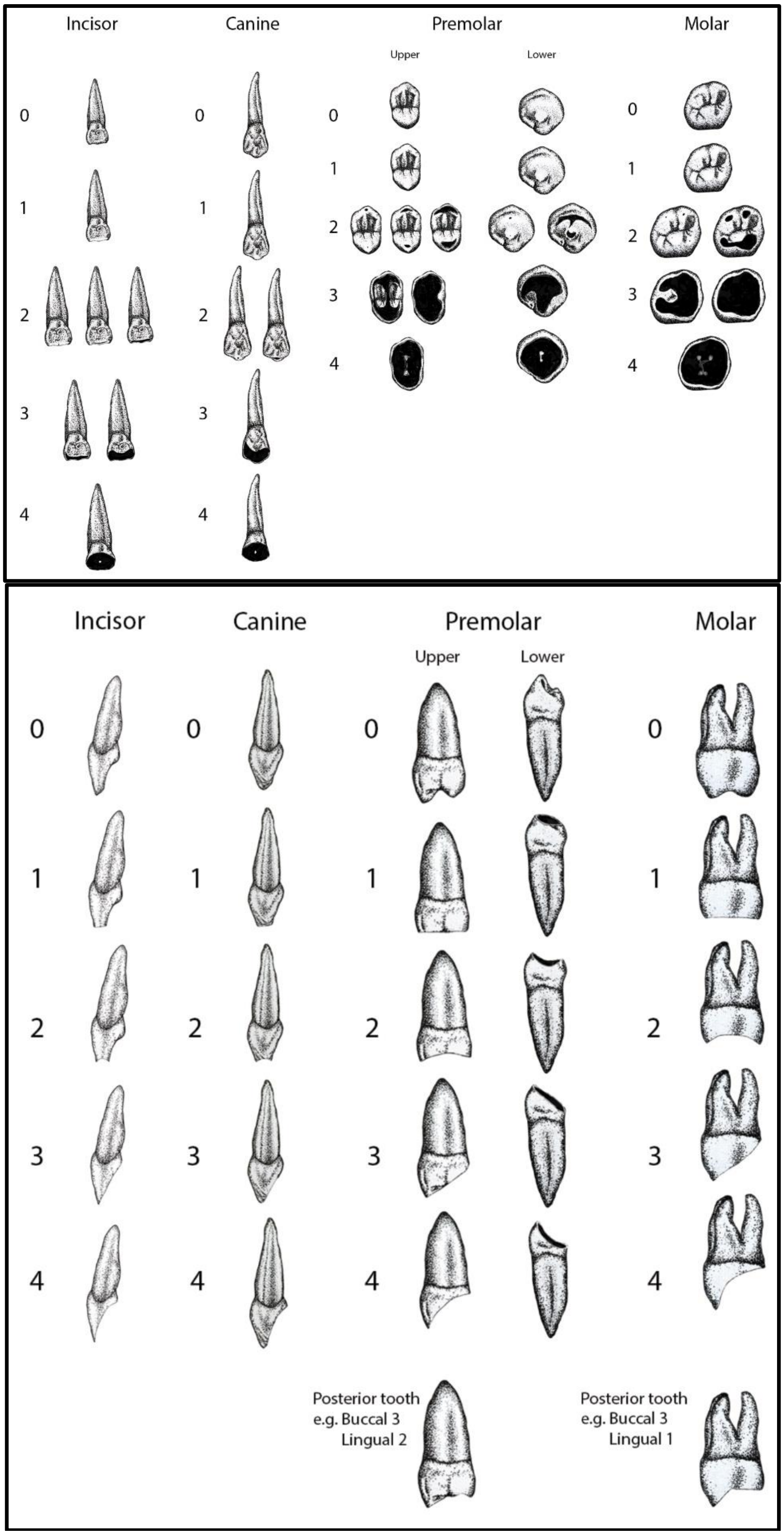


Figure 5.1: Brabant index visual guide for dental wear quantity (top) and direction (bottom)—author's artistic impression of dental wear stages [Drawing by Olszewski in 2021]. Stages are divided into four scores: gradually increasing in wear quantity (top) or changing in wear direction (bottom). Two additional examples demonstrate wear direction on the bottom right, indicating wear stages differ between buccal and lingual cusps on multicuspid teeth.

5.2 Method repeatability discussion

The Brabant index is a simple and user-friendly method; however, the reliability assessments highlighted replicability issues that improved upon incorporating multicuspid scoring and a visual guide. Considering a primary objective of this thesis was dental wear examination, this section evaluates the Brabant index and discusses the incorporated methodological adjustments and creation of a visual guide.

Significant methodological errors may reduce the scientific value of research data, where inaccurate replication of an osteological method may be due to several factors: population variation (İşcan & Loth, 1986a,b; Oettlé & Steyn, 2000; Esan & Schepartz, 2018), demographic variation (e.g., a sample consisting only of males, as opposed to all sexes) (Buckberry & Chamberlain, 2002), and as demonstrated in these results, varying observer experience. Researchers often revise standardised dental wear methodologies to suit different populations or objectives (Gustafson & Malmö, 1950; Johanson, 1971; Brothwell, 1981; Smith, 1984; Lovejoy, 1985; Bartholdy, Hoogland & Waters-Rist, 2019; Olszewski, 2019). Brabant (1966) first conducted the index on a European reference population dating to the 15th to 19th centuries and included individuals aged six to 50+ years. The population predictably demonstrated little to moderate wearing, considering the study included children and due to the dietary habits of the population. Wherein wear results akin to Brabant's publication have also been prevalent in other studies that used the index on samples from similar periods (Chazel et al., 2005; Singh Sehrawat & Singh, 2018; Nedoklan et al., 2020). Overall, the index helps provide a holistic understanding of a population's wear patterns.

Although the Brabant index intends to be a simplified and user-friendly system for recording dental wear, a recurring issue for ordinal classification systems consists of subjectivity biases between observers (Bruzek, 2002). However, standardised criteria have reduced biases and allowed features or characteristics to be objectively assessed (Buckberry & Chamberlain, 2002). Researchers have only applied the Brabant index using a text format, descriptively elaborating on different wear scores. Several studies (Lucas et al., 2011; Esclassan et al., 2015; Grimoud & Gibbon, 2017; Singh Sehrawat & Singh, 2018) have included some photographic examples of different Brabant index stages; however, not every study that used the index has utilised both quantity and direction. The original publication (Brabant, 1966) introduced the index in a written format and was in French. Over the decades, the index has endured several modifications, both in French and in English, where wording changes slightly between authors. For example, Esclassan and colleagues (2009) presented the Brabant index in French and Gibbon and Grimoud (2014) presented the index in English but the translations between the two studies are slightly different. For example, stage two for Esclassan and colleagues (2009: 11) translates to ‘dentine partially exposed’ or ‘partial dentine wear’, “*Dentine partiellement exposée*”, whereas Gibbon and Grimoud (2014: 442) write: “Level 2: presence of dentine clusters”, which is more specific. Similarly, stage four: “*Exposition pulpaire*” for Esclassan and colleagues (2009: 11) translates to pulpal exposure and Gibbon and Grimoud (2014: 442) wrote “Level 4: involvement of pulp horns or exposure”. Nedoklan and colleagues (2020) described index stages similarly to Gibbon and Grimoud (2014). Whereas Lucas and colleagues (2011) present the index similarly to Esclassan and colleagues (2009), and where their stage four is slightly different: “*usure exposant la pulpe*” (Lucas et al., 2011: 180) translating to “wear exposing the pulp’, it still suggests ‘pulp exposure’. Notably, some studies do not present the index descriptions, but cite the index from its original study, thus, not clarifying which translation or descriptive stages have been referenced (Esclassan et al. 2015). Where these studies are only a few comparative examples and differences between translations are marginal, interpretations of the descriptions themselves still differ and risk misunderstanding over time. Consequently, visual guides mitigate for written differences and subjectivity.

To mitigate this issue for consistency and future research, I designed and created a Brabant index visual guide and included separate buccal and lingual scores for multicuspid teeth. Although scoring each quadrant was considered, the rate of wear on the entire occlusal surface for HGH teeth was rapid (Smith, 1984), and it was noted early in this project that each tooth quadrant rarely demonstrated a uniquely different wear pattern. Furthermore, overcomplicating the data would decrease statistical power within an already skewed sample distribution. Importantly, applying the adjusted Brabant index in practice required some experience with dentition, as apparent with O1’s slight decrease in repeatability reliability with the modified method, where implementing more scorable elements may have contributed to inaccuracies by an inexperienced observer. With greater experience (author and O2), the tooth identification process was facilitated by an understanding of the unique anatomy and orientation of each tooth. As a result, the tedious adjustments to the method through the creation of a visual guide and multicuspid scoring improved the accuracy and reliability of this method for a more experienced observer.

The repeatability results were presented earlier in this chapter, where improvements in accuracy were prevalent for experienced observers following methodological adjustments. One factor that warranted the optimisation of the index was a lack of visual guidance. Several wear studies using other methods have included visual depictions of the scores and at least eight stages of wear to account for various visual forms of dental tissue loss on the occlusal surface (Brothwell, 1981; Bartholdy, Hoogland & Waters-Rist, 2019; Olszewski, 2019), thus accounting for any indistinct phases between scores in the wearing process. For this thesis, providing several examples for each wear stage helped reduce the chances of subjectivity bias around ambiguous stages of wear. Further, implementing multicuspid scores allowed an observer to score both cusps independently without adding new wear stages to the humble four-stage index. The cusps of posterior teeth wear at different rates, affected by mandibular motion that adjusts relative to a consumed food type (e.g., soft, fibrous, tough) (Smith, 1984; Górka, 2016). Standard wear development typically affects the maxillary lingual surface ahead of the buccal surface. Conversely, the mandibular buccal side wears ahead of the lingual side (Smith, 1984), and overall wear rapidly advances in HGH populations that consume a diet of tougher food types, resulting in rapid dentine and pulp chamber exposure (Molnar et al., 1972). Therefore, one side of a multicuspid tooth wears more slowly and can exhibit a different quantity or direction stage for longer. As wear advances, particularly in populations with softer diets, the mandibular buccal and maxillary lingual cusps tend to produce oblique wear, where the opposing surfaces can remain horizontal (Grimoud & Gibbon, 2017), notwithstanding examples of localised abrasion from environmental contaminants (Lee et al., 2012), using teeth as tools, and intrinsic oral habits such as bruxism (Burnett, 2016). As a result, multicuspid scores on a population that exhibited examples of heavy and non-masticatory wear were demonstrated as useful to improve the accuracy of a dental wear method with few but broad wear stages. It is further recommended that recording notes alongside scores is of use to the researcher and future observers, to distinguish deviations from expectations, reporting obstructed visibility or recording whether there is a hole in the dentine to elaborate upon the stage of pulpal exposure. These population-specific aspects of wearing were considered and warranted the optimisation of the Brabant index. This section highlighted the benefits of adjustments to standardised methodologies in the form of visual guides and multicuspid scoring to better suit population and behavioural variation.

5.3 Dental wear quantity

Dental wear quantity was scored for 6107 teeth and 10,209 occlusal surfaces (Figure 5.2 and Table 5.2). The mean wear for the entire sample was 2.3, correlating with partial dentine exposure, and Table 5.3 presents this value with previously published means. Mean wear for the anterior teeth was 2.6, 2.1 for posterior teeth, and buccal and lingual 2.1, respectively, correlating with partial dentine exposure. The means were insignificant using a paired *t*-test between buccal and lingual scores. The relative number of surfaces scored between maxillae and mandibles were 50% (maxillae: 5126/10209; mandibles: 5083/10209). Concerning quantity scores, dentine partially exposed was the most frequent stage on 40% (4042/10209) of surfaces, followed by enamel polishing on 25% (2534/10209), and a relatively equal representation of 17% for complete dentine exposure and pulp chamber exposure (1728/10209; 1745/10209, respectively). Absence of wear was scored on 2% (160/10209) of surfaces and was most frequently observed on the third molars, accounting for 30% of buccal (48/160) and 36% of lingual (58/160) third molar surfaces. Anterior teeth did not show absence of wear, nor did the buccal second premolar surface or the buccal and lingual first molars. Moreover, enamel polishing was also most frequently noted on the third molars, accounting for 16% of buccal (415/2534) and lingual (401/2534) surfaces, and it was observed once on the central incisors, which aligned with tooth eruption times, where incisors would erupt before third molars. The first molars most frequently had partial and total dentine exposure. Conversely, partial and total dentine exposure were observed infrequently on the third molars, along with having lower incidence rates for teeth with pulp chamber exposure (1%, buccal: 12/1745; lingual: 21/1745). Pulp chamber exposure was predominantly observed on anterior teeth, particularly the canines, which represented 16% (276/1745), and 14% for the central (236/1745) and lateral (251/1745) incisor surfaces, potentially due to tool-use.

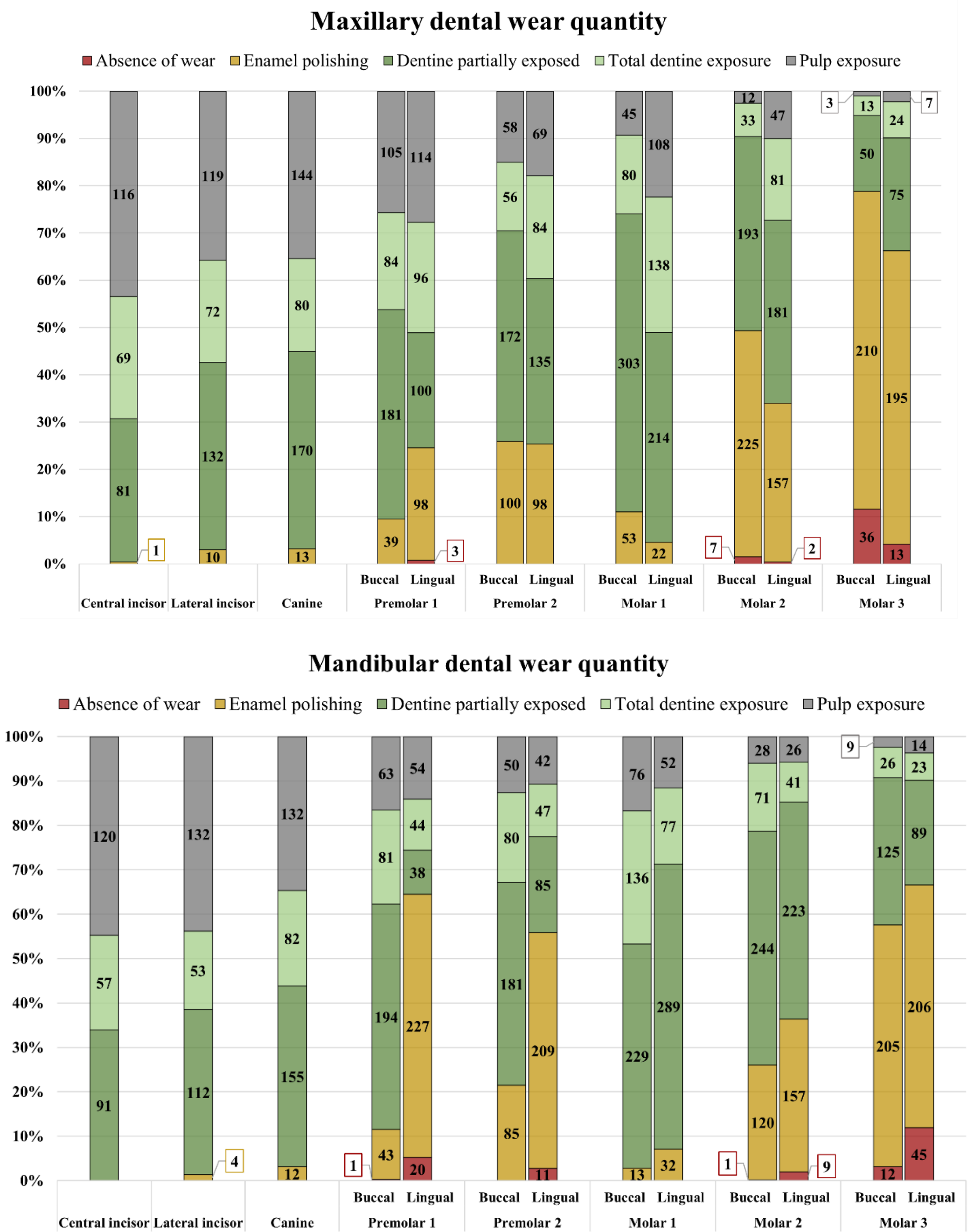


Figure 5.2: Frequency of dental wear quantity for maxillae and mandibles. The vertical axis presents relative frequencies expressed in percentage, and data labels in bars demonstrate frequency.

Table 5.2: Dental wear quantity frequency of Brabant index scores per tooth category.

Dental wear quantity			Stage 0	Stage 1	Stage 2	Stage 3	Stage 4	*Totals**	
			n	*n*	*n*	*n*	*n*	***n***	%
Maxilla	**Central Incisor**		0	1	81	69	116	267	5
	Lateral Incisor		0	10	132	72	119	333	6
	Canine		0	13	170	80	144	407	8
	Premolar 1	Buccal	0	39	181	84	105	409	8
		Lingual	3	98	100	96	114	411	8
	Premolar 2	Buccal	0	100	172	56	58	386	8
		Lingual	0	98	135	84	69	386	8
	Molar 1	Buccal	0	53	303	80	45	481	9
		Lingual	0	22	214	138	108	482	9
	Molar 2	Buccal	7	225	193	33	12	470	9
		Lingual	2	157	181	81	47	468	9
	Molar 3	Buccal	36	210	50	13	3	312	6
		Lingual	13	195	75	24	7	314	6
	Totals*	***n***	61	1221	1987	910	947	**5126**	
		%	1	24	39	18	18		**100**
Mandible	**Central Incisor**		0	0	91	57	120	268	5
	Lateral Incisor		0	4	112	53	132	301	6
	Canine		0	12	155	82	132	381	7
	Premolar 1	Buccal	1	43	194	81	63	382	8
		Lingual	20	227	38	44	54	383	8
	Premolar 2	Buccal	0	85	181	80	50	396	8
		Lingual	11	209	85	47	42	394	8
	Molar 1	Buccal	0	13	229	136	76	454	9
		Lingual	0	32	289	77	52	450	9
	Molar 2	Buccal	1	120	244	71	28	464	9
		Lingual	9	157	223	41	26	456	9
	Molar 3	Buccal	12	205	125	26	9	377	7
		Lingual	45	206	89	23	14	377	7
	Totals*	***n***	99	1313	2055	818	798	**5083**	
		%	2	26	40	16	16		**100**

*Percentages calculated against total scores for maxilla (n = 5126) in maxilla section or total scores for mandible (*n* = 5083) in mandible section; *n* = sample size.

Stage 0: Absence of wear
Stage 1: Enamel polishing
Stage 2: Dentine partially exposed in clusters
Stage 3: Total dentine exposure
Stage 4: Pulp chamber exposure

Table 5.3: Mean wear for dental wear quantity in this study and additional published sAHGH studies.

Mean wear index for dental wear studies		Reported mean wear index	Converted to Brabant index*	Sample size (n)	Original scoring system
This study		2.3	N/A	369	Brabant index (1966)
Morris, 1992a	Riet river	2.4	2	51	Adapted Brothwell (1981)
	Kakamas	2.1	2	43	Adapted Brothwell (1981)
	Griqua	1.6	1 or 2	26	Adapted Brothwell (1981)
Van Reenen, 1964		2	2	104	Adapted Brothwell (1981)
Drennan, 1929		2.8	2 or 3	28	Adapted Brothwell (1981)
Pfeiffer et al., 2020		4.6	2	7	Smith (1984)
Sealy and van der Merwe, 1988		2.3	2	49	Brothwell (1981)
Botha and Steyn, 2015		3.8	2	39	Molnar (1971)
Sealy et al., 1992		2.4	2	67	Adapted Brothwell (1981)

*Values are adapted to correspond with the modified Brabant index.
†Select contact period populations are included as they represented 'San and Khoe' remains and provided comparative scores to precontact samples.

Table 5.4: Mean dental wear quantity across all demographics.

	Variable	Anterior teeth	Posterior teeth	Overall
Sex	Female	2.9	2.0	2.2
	Male	3.0	2.0	2.3
Age	Young adult	2.7	1.7	1.9
	Young/middle adult	2.8	1.8	2.0
	Middle adult	3.0	2.1	2.3
	Middle/old adult	3.0	2.2	2.4
	Old adult	3.3	2.7	2.8
Spatial	Coastal	3.0	2.0	2.3
	Inland	2.8	1.9	2.1
Pre/post-2000 BP	Pre-2000 BP	3.0	2.1	2.3
	Post-2000 BP	3.1	2.0	2.2
Holocene divisions	Earlier Holocene	3.0	2.1	2.3
	Middle Holocene	3.0	2.1	2.3
	Later Holocene	3.1	2.0	2.2

Males had more occlusal surfaces (55%; 4595/8355) available for scoring than females (45%, 3760/8355) for sexed individuals, and overall male wear was 2.3 and female mean wear was 2.2 (Figure 5.3; Table 5.4, respectively), both in the range of partial dentine exposure. The difference between the distribution of dental wear quantity scores for maxillae and mandibles was insignificant; however, sex by maxillae and mandibles in Figure 5.3 demonstrates slight differences in frequencies between tooth types. The most frequently scored stage for both sexes was partial dentine exposure, followed by enamel polishing, and total dentine exposure and pulp exposure were almost equally represented for both sexes. Dentine partially exposed was most frequently noted on both sexes' first and second molars, and pulp exposure was most frequently scored on the anterior teeth, except for the lingual side of the maxillary first molars and the buccal side of the mandibular first molars.

Wear surfaces were most frequently recorded for young/middle and middle/old-aged adults, groups that also predominated sampling distribution for age categories. Of aged individuals, young adults represented 6% (337/5632) of scores, young/middle-aged adults represented 42% (2349/5632) of scores, middle-aged adults with 21% (1186/5632) of scores, middle/old-aged adults with 27% (1542/5632) of scores, and old-aged adults with 4% (218/5632) of scores (Figure 5.4). The most frequent score for almost all age groups was dentine partially exposed, except for young adults, who showed enamel polishing as the most frequent score. Mean wear increased with each subsequent age group, where young adults had a mean of 1.9 (enamel polishing), and old adults had a mean of 2.8 (partial dentine exposure) (Table 5.4). Differences between distributions of aged dental wear quantity scores for maxillae and mandibles were insignificant. These results supported the expected pattern where higher wear quantity scores occurred more frequently in older adults than younger adults. However, inconsistent means were revealed with anterior mean wear in middle and middle/old adults, both being 3, potentially due to sampling distribution where middle/old adults included more middle adults or increased presence of anterior tooth loss in an age group. Between all age groups, the most prevalent stages were typically observed on the posterior teeth.

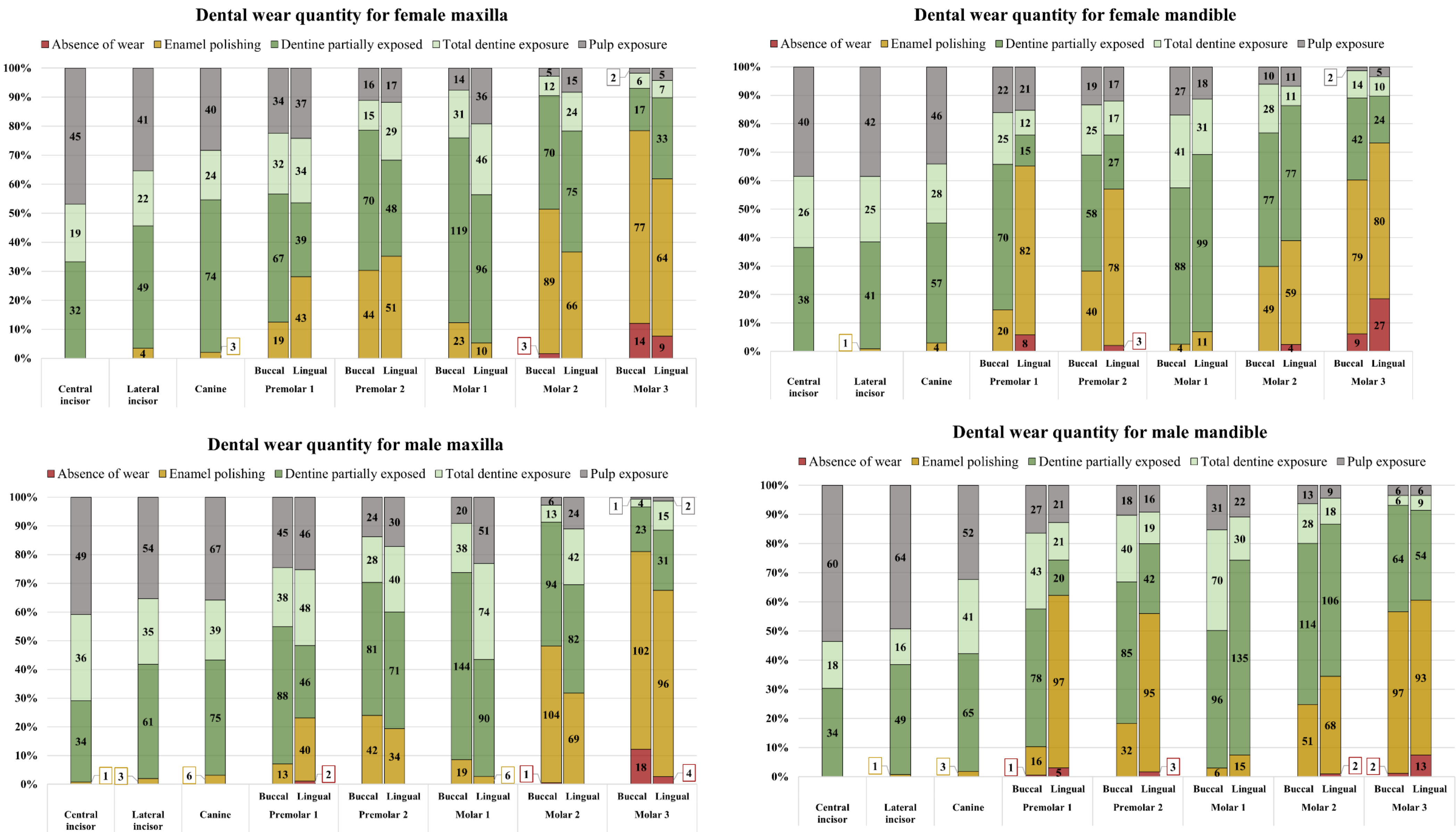


Figure 5.3: Frequency of dental wear quantity for female (top) and male (bottom) maxillae and mandibles by tooth category. The vertical axis presents relative frequencies expressed in percentage, and data labels in bars demonstrate frequency.

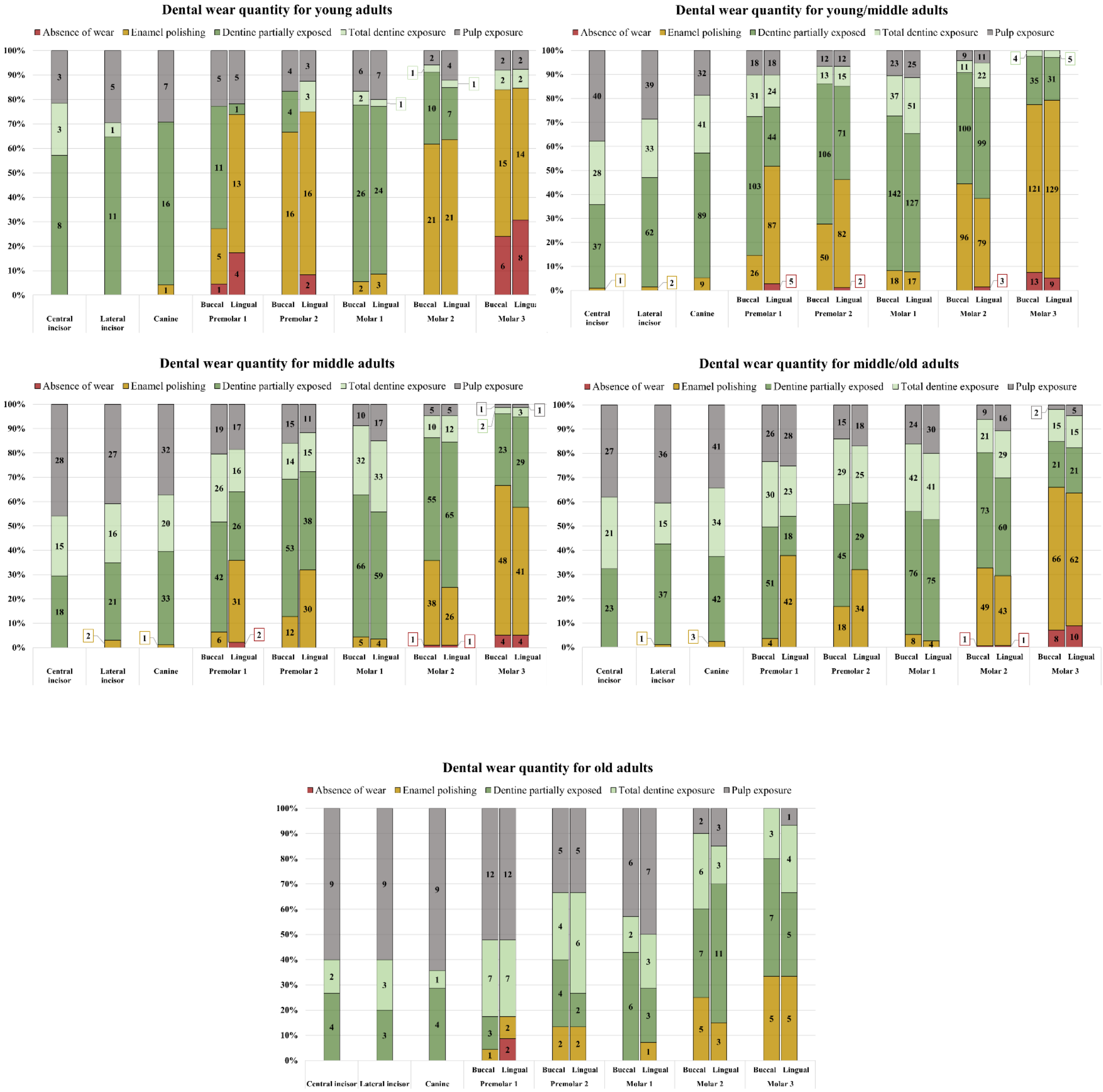


Figure 5.4: Frequency of dental wear quantity for age-at-death groups. From top left to right: young adults, young/middle adults, middle adults, middle/old adults, and old adults (bottom). The vertical axis presents relative frequencies expressed in percentage, and data labels in bars demonstrate frequency.

In provenanced individuals, coastal individuals were most frequently scored for quantity, with 86% (8716/10101) quantity scores, compared to inland individuals with 14% (1385/10101) (Figure 5.5). Wear quantity between regions exhibited a mean of 2.3 for coastal and 2.1 for inland individuals (Table 5.4). Differences between distributions of dental wear quantity scores for maxillae and mandibles were insignificant. Dentine partially exposed was the most frequently noted stage for both spatial regions, with the remaining stages demonstrating similar relative frequencies across the dentition. One exception included inland first molars, which demonstrated a marked increase in pulp chamber exposure, 12% (19/158) for buccal and 19% (30/158) for lingual surfaces, compared to coastal individuals with 6% (101/1559) for buccal and 8% (129/1559) for lingual first molars.

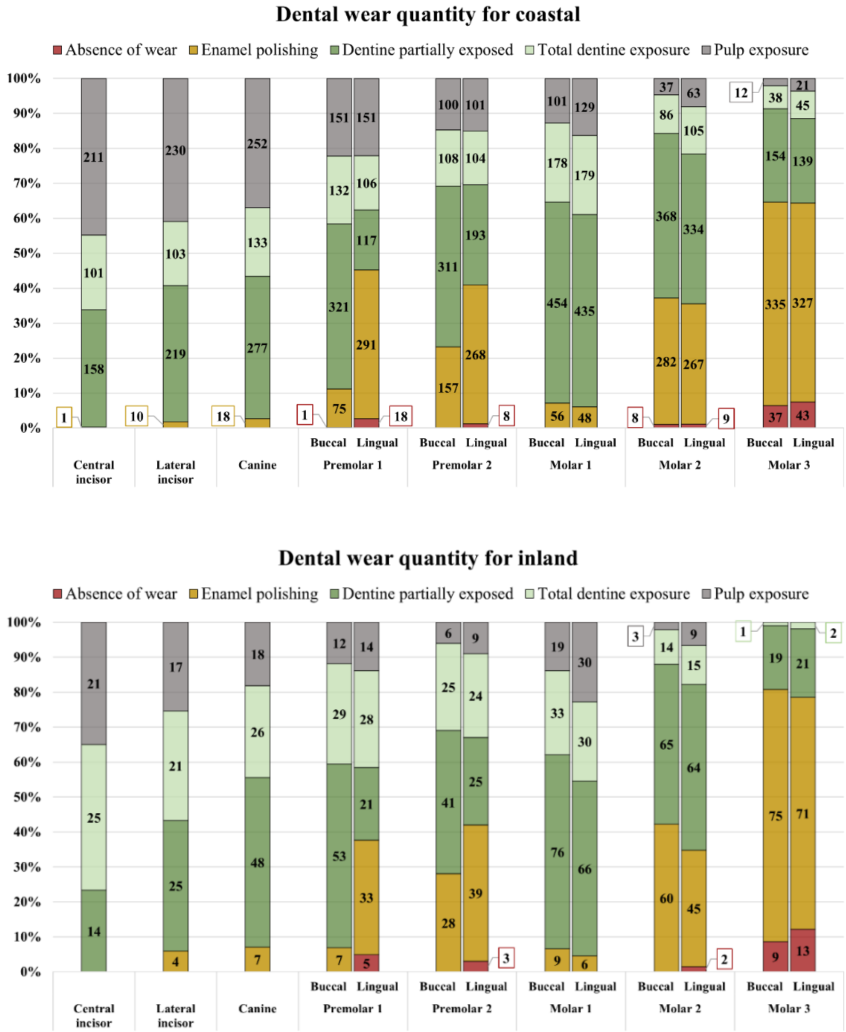


Figure 5.5: Frequency of dental wear quantity for coastal (top) and inland (bottom) spatial regions. The vertical axis presents relative frequencies expressed in percentage, and data labels in bars demonstrate frequency.

More occlusal surfaces were scored for pre-2000 BP (59%; 5027/8528) compared to post-2000 BP (41%; 3501/8528) (Figure 5.6), and differences between distributions of quantity scores for maxillae and mandibles were insignificant. Mean wear were similar, as pre-2000 BP had 2.3 compared to 2.2 in post-2000 BP individuals (Table 5.4). For both periods, dentine partially exposed was most frequently scored, although for subsequent frequent stages, there was a higher representation of pulp chamber exposure in pre-2000 BP (20%; 989/5027) instead of complete dentine exposure 16%; 818/5027). These results differed from post-2000 BP, where complete dentine exposure was more frequently scored (18%; 632/3501) before pulp chamber exposure (15%; 522/3501). Between both temporal periods, there were similar distributions of wear on tooth types and more frequent pulp chamber exposure on all anterior teeth compared to posterior teeth.

Scored surfaces for the middle Holocene were 45% (3832/8528), 41% (3501/8528) for the later Holocene, and 14% (1195/8528) for the earlier Holocene (Figure 5.7). There was a significant relationship between the distributions of the variables between maxillae and mandibles, $\chi2(2, 8528) = 10.592$, p=0.004. Mean wear mimicked pre/post-2000 BP and was identical between the earlier and middle Holocene (2.29) (Table 5.4). Similar observations were apparent as noted for pre/post-2000 BP, particularly with dentine partially exposed being scored most frequently, and subsequently, pulp chamber exposure being scored ahead of total dentine exposure in the earlier (243/1195) and the middle (746/3832) Holocene, compared to the converse in the later Holocene. The earlier Holocene had 20% (243/1195) scores with pulp chamber exposure compared to 16% (186/1195) of total dentine exposure, and the middle Holocene had 19% (746/3832) scores with pulp chamber exposure compared to 16% (632/3832) of scores with total dentine exposure. Conversely, the later Holocene had fewer scores with pulp chamber exposure, 15% (522/3501), compared to more scores of total dentine exposure, 18% (632/3501). Absence of wear and enamel polishing was most frequently observed on the third molars across all divisions, in line with their late eruption time, with the most frequent occurrences in the later Holocene (20% in buccal: 179/895 and lingual: 180/895) surfaces. Like pre/post-2000 BP, all anterior teeth demonstrated pulp chamber exposure ahead of the posterior teeth across the Holocene.

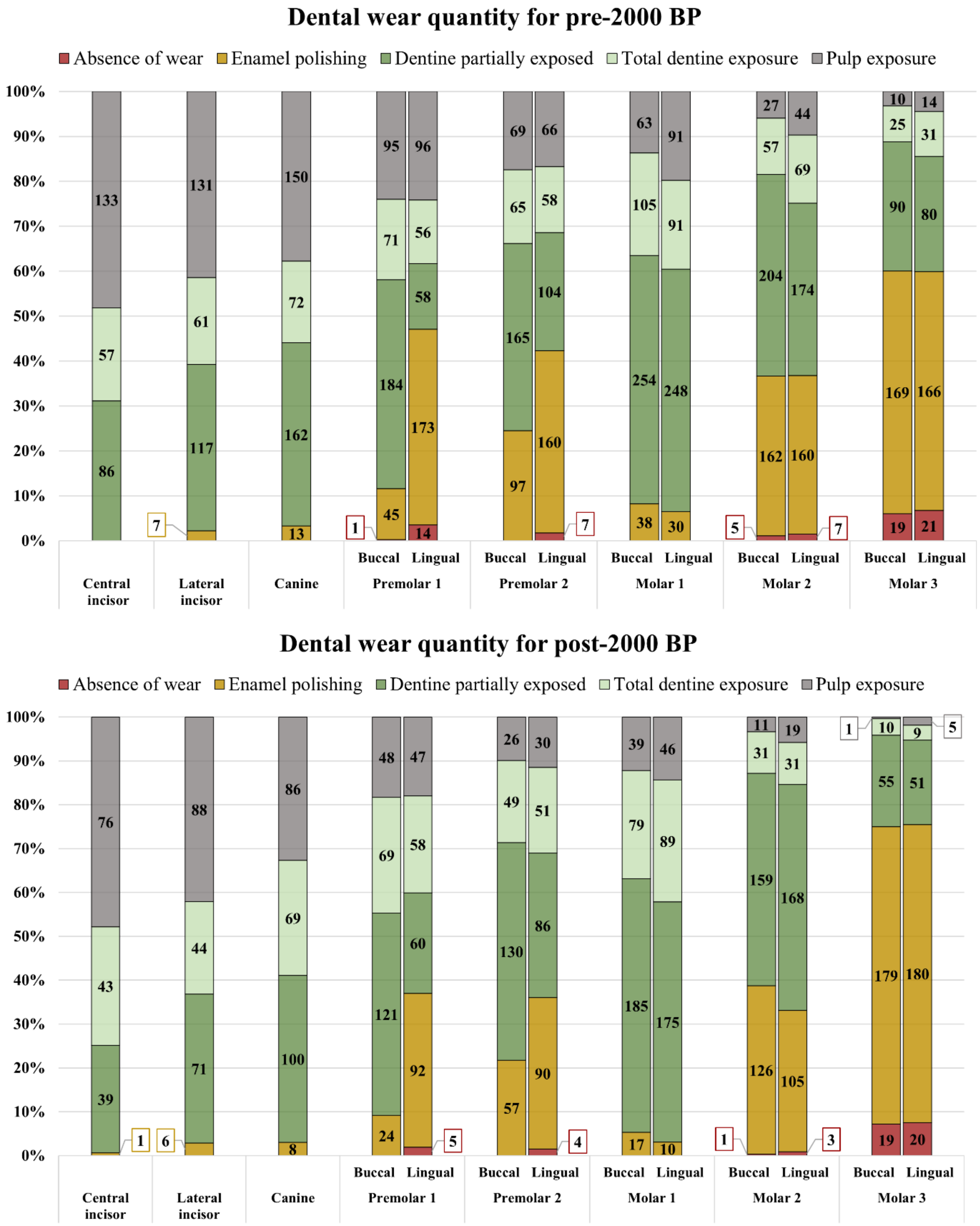


Figure 5.6: Frequency of dental wear quantity for temporal periods of pre-2000 BP (top) and post-2000 BP (bottom). The vertical axis presents relative frequencies expressed in percentage, and data labels in bars demonstrate frequency.

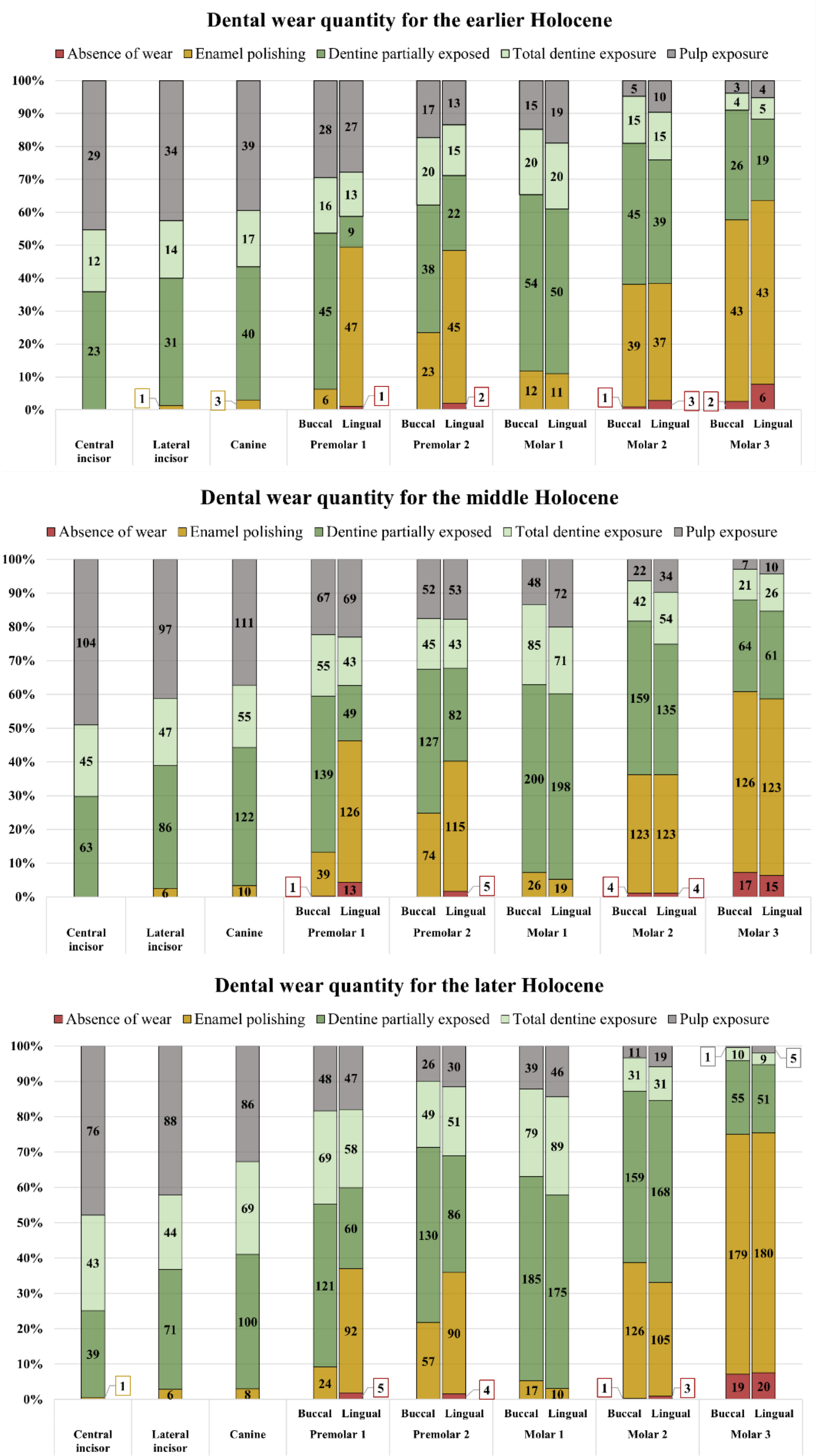


Figure 5.7: Frequency of dental wear quantity for Holocene divisions with the earlier Holocene (top), the middle Holocene (middle), and the later Holocene (bottom). The vertical axis presents relative frequencies expressed in percentage, and data labels in bars demonstrate frequency.

5.3.1 Multiple factors and their effect on wear quantity

The development of dental wear quantity for tooth type and arcade was assessed with a cumulative link mixed model fitted with the Laplace approximation formula, with the individual term being the random effect (Tables 5.5 and 5.6). Initial interaction terms significantly reduced the odds of increasing wear quantity for all tooth types when the central incisor remained in the baseline category. The maxillary first and second premolars and first molars demonstrated appreciably increased odds for greater wear quantity (Upper PM1: OR=3.7, $p \leq 0.001$; Upper PM2: OR=2.4, $p \leq 0.001$; Upper M1: OR=1.68, $p=0.004$). When all teeth were assessed simultaneously, maxillae did not exhibit appreciable results. Based on these findings, the arcade and individual molars were retained for further analyses. The remaining tooth types were collapsed into morphological categories of anterior dentition (incisors and canines) and premolars to reduce the number of factors, where the premolars became the reference category. Collapsing certain tooth groups to reduce the number of factors reduced the AIC from 9130.59 to 4930.61.

Table 5.5: Regression results on effects of tooth type and arcade on dental wear quantity. OR=Odds ratio; The individual (random effect) had a variance of 10.96. Significance levels: * ≤ 0.05, ** ≤ 0.01, *** ≤0.001.

Factors	Estimate	OR	Std. Error	z value	*p*-value	
Later incisor	-0.7737	0.46	0.2066	-3.774	0.000181	***
Canine	-1.5866	0.20	0.1949	-8.139	3.98×10^{-16}	***
Premolar 1	-3.4010	0.03	0.1992	-17.073	$<2 \times 10^{-16}$	***
Premolar 2	-4.1449	0.015	0.2023	-20.491	$<2 \times 10^{-16}$	***
Molar 1	-2.2210	0.108	0.1908	-11.641	$<2 \times 10^{-16}$	***
Molar 2	-4.9043	0.007	0.2036	-24.092	$<2 \times 10^{-16}$	***
Molar 3	-7.7976	0.0004	0.2427	-32.126	$<2 \times 10^{-16}$	***
Maxillary premolar 1	1.3198	3.74	0.2719	4.855	1.21×10^{-6}	***
Maxillary premolar 2	0.8771	2.40	0.2717	3.228	0.001	**
Maxillary molar 1	0.5230	1.687	0.2646	1.0976	0.048	*

Table 5.6: Threshold coefficients for the first wear quantity regression model.

Threshold coefficients				
Score	**Estimate**	**OR**	**Std. Error**	**z value**
1	-15.03045	2.967	0.41354	-36.346
2	-8.09986	0.0003	0.28184	-28.739
3	-2.73895	0.0646	0.25102	-10.911
4	-0.09962	0.905	0.24645	-0.404

A model regression was performed again with the individual as the random effect to assess select demographic factors on increasing dental wear quantity (Tables 5.7 and 5.8). Only certain age categories had appreciable effects when assessing initial interaction terms with age and spatial categories. Both young adults demonstrated reduced odds of increasing wear quantity (OR=0.05, p=0.01). Whereas young/middle-aged adults also demonstrated notably reduced odds, although these results were not significant by way of a 95% p-value cut-off (OR=0.29; p=0.07), and old-aged adults demonstrated notably increased odds, although insignificant by a 95% cut-off (OR=8.45, p=0.09). Of tooth types, similar patterns of association were retained, yet, of note were greater odds of increasing wear quantity in the first molars (OR=4.64, $p \leq 0.001$), for the anterior teeth (OR=18, $p \leq 0.001$) and for the entire maxilla (OR=2.12, $p \leq 0.001$). The model presented appreciable results for reduced odds in the maxillary second and third molars (OR=0.53, p=0.01; OR=0.3, $p \leq 0.001$) and reduced odds for the combined maxillary anterior teeth (OR=0.31, $p \leq 0.001$) compared to the mandibular anterior teeth.

Table 5.7: Regression results on effects of tooth type, collapsed tooth categories, arcade, age and spatial for dental wear quantity. OR=Odds ratio; The individual (random effect) had a variance of 11.02. Significance levels: **.** ≤ 0.1, * ≤ 0.05, ** ≤ 0.01, *** ≤0.001.

Factors	Estimate	OR	Std. Error	z value	*p*-value	
Molar 1	1.5368	4.649	0.1856	8.278	$<2x10^{-16}$	***
Molar 2	-1.2237	0.294	0.1880	-6.509	$7.55x10^{-11}$	***
Molar 3	-4.3206	0.013	0.2377	-18.177	$<2x10^{-16}$	***
Anterior teeth	2.8959	18.099	0.1680	17.234	$<2x10^{-16}$	***
Maxilla	0.7525	2.12	0.1612	4.667	$3.05x10^{-6}$	***
Old adult	2.1350	8.457	1.2765	1.673	0.09	**.**
Young adult	-2.9030	0.0548	1.1624	-2.497	0.01	*
Young/middle adult	-1.2162	0.2963	0.6796	-1.790	0.07	**.**
Maxillary molar 2	-0.6177	0.539	0.2623	-2.355	0.01	*
Maxillary molar 3	-1.1971	0.302	0.3113	-3.845	0.00012	***
Maxillary anterior	-1.1471	0.317	0.2203	-5.206	$1.93x10^{-7}$	***

Table 5.8: Threshold coefficients for the second wear quantity regression model.

Threshold coefficients				
Score	**Estimate**	**OR**	**Std. Error**	**z value**
1	-11.8601	0.000007	0.6999	-16.945
2	-4.6713	0.00936	0.5732	-8.150
3	0.7694	2.158	0.5621	1.369
4	3.4131	30.359	0.5672	6.018

When pre/post-2000 BP replaced the spatial factor, the AIC reduced to 4346.47, improving the model's fit. Although the previous model’s patterns of association were retained, many logits (OR) increased (Tables 5.9 and 5.10). Most notably, old-aged adults exhibited significantly greater odds for increasing wear (OR=18.7, p=0.03) than in previous models. The lack of appreciable effects when including pre/post-2000 BP was reiterated when including Holocene divisions.

Table 5.9: Regression results on effects of tooth type, collapsed tooth categories, arcade, age and pre/post-2000 BP for dental wear quantity. OR=Odds ratio; The individual (random effect) had a variance of 10.96.
Significance levels: **.** ≤ 0.1, * ≤ 0.05, ** ≤ 0.01, *** ≤0.001.

Factors	**Estimate**	**OR**	**Std. Error**	**z value**	***p*-value**	
Molar 1	1.4789	4.388	0.1960	7.543	4.58×10^{-14}	***
Molar 2	-1.1949	0.3027	0.1981	-6.033	1.61×10^{-9}	***
Molar 3	-4.3958	0.0123	0.2532	-17.359	$<2 \times 10^{-16}$	***
Anterior teeth	2.9819	19.725	0.1788	16.674	$<2 \times 10^{-16}$	***
Maxilla	0.7518	2.1208	0.1714	4.385	1.16×10^{-5}	***
Old adult	2.9327	18.778	1.3610	2.155	0.03	*
Young adult	-2.6038	0.07399	0.9745	-2.672	0.007	**
Young/middle adult	-1.1622	0.3127	0.6721	-1.729	0.08	**.**
Maxillary molar 2	-0.6693	0.512	0.2779	-2.408	0.01	*
Maxillary molar 3	-1.2580	0.284	0.3345	-3.761	0.0001	***
Maxillary anterior	-1.0729	0.342	0.2344	-4.577	4.71×10^{-6}	***

Table 5.10: Threshold coefficients for the third wear quantity regression model.

Threshold coefficients				
Score	**Estimate**	**OR**	**Std. Error**	**z value**
1	-11.9040	0.000006	0.8246	-14.436
2	-4.3172	0.0133	0.6788	-6.360
3	1.0608	2.888	0.6718	1.579
4	3.7011	40.491	0.6791	5.450

5.4 Dental wear direction

Dental wear direction was scored for 6183 teeth and 10,375 occlusal surfaces (Table 5.11 and Figure 5.8). Between maxillae and mandibles, the relative number of surfaces scored was 50% (maxillae: 5191/10375; mandibles: 5184/10375). Horizontal and plane was overwhelmingly frequent, observed on 80% (8321/10375) of all surfaces assessed. The remaining stages represented low overall frequencies: 8% (845/10375) of oblique and plane, 6% (578/10375) of absence of wear direction, 5% (561/10375) of horizontal and concave, and 1% (70/10375) of oblique and concave. Horizontal and plane was distributed relatively equally across all tooth types and between cusps for the entire dental arcade, though its greatest representation was 9% on the first (buccal 742/8321; lingual 720/8321) and second (buccal 746/8321; lingual 729/8321) molar surfaces, possibly correlated with mastication in the posterior teeth and earlier eruption times. Horizontal and concave was most apparent on the lingual surface of the first and second molars, with 24% (136/561) on the lingual first molar surface and 19% (105/561) on the lingual second molar surface. Oblique and plane were observed most frequently on the canines (12%; 98/845), followed by the buccal first molar surface (11%; 95/845) and then lateral incisors (10%; 83/845). Oblique and concave were most prevalent on the entire surface of the first molars (buccal: 21%, 15/70; lingual: 16%, 11/70), followed by the second molars (buccal: 13%, 9/70; lingual: 11%, 8/70), potentially from abrasion. Absence of direction was most frequently observed on all surfaces of the third molars (buccal: 25%, 143/578; lingual: 26%, 152/578), in line with the late eruption of the tooth type.

Table 5.11: Dental wear direction frequency of Brabant index scores per tooth category.

Dental wear direction			Stage 0	Stage 1	Stage 2	Stage 3	Stage 4	*Totals**	
			n	*n*	*n*	*n*	*n*	***n***	%
Maxilla	**Central Incisor**		0	208	4	54	3	269	5
	Lateral Incisor		1	274	3	56	1	335	6
	Canine		6	317	11	74	3	411	8
	Premolar 1	Buccal	11	336	10	54	5	416	8
		Lingual	21	337	17	38	3	416	8
	Premolar 2	Buccal	12	339	5	30	3	389	7
		Lingual	16	329	12	30	3	390	8
	Molar 1	Buccal	3	392	30	57	6	488	9
		Lingual	1	367	80	35	6	489	9
	Molar 2	Buccal	26	363	31	53	6	479	9
		Lingual	18	379	44	29	6	476	9
	Molar 3	Buccal	81	212	12	9	1	315	6
		Lingual	68	233	4	12	1	318	6
	Totals*	***n***	264	4086	263	531	47	**5191**	
		%	5	79	5	10	1		**100**
Mandible	**Central Incisor**		0	252	5	16	0	273	5
	Lateral Incisor		2	273	2	27	1	305	6
	Canine		6	348	5	24	0	383	7
	Premolar 1	Buccal	14	353	11	11	0	389	8
		Lingual	60	292	6	32	0	390	8
	Premolar 2	Buccal	8	366	7	24	0	405	8
		Lingual	25	351	5	21	1	403	8
	Molar 1	Buccal	0	350	65	38	9	462	9
		Lingual	2	353	56	43	5	459	9
	Molar 2	Buccal	20	383	40	27	3	473	9
		Lingual	31	350	61	23	2	467	9
	Molar 3	Buccal	62	301	9	15	1	388	7
		Lingual	84	263	26	13	1	387	7
	Totals*	***n***	314	4235	298	314	23	**5184**	
		%	6	82	6	6	0		**100**

*Percentages calculated against total scores for maxillae (*n* = 5191) in maxilla section or total scores for mandibles (*n* = 5184) in mandible section; *n* = sample size.

Stage 0: Absence of wear direction
Stage 1: Horizontal and plane
Stage 2: Horizontal and concave
Stage 3: Oblique and plane
Stage 4: Oblique and concave

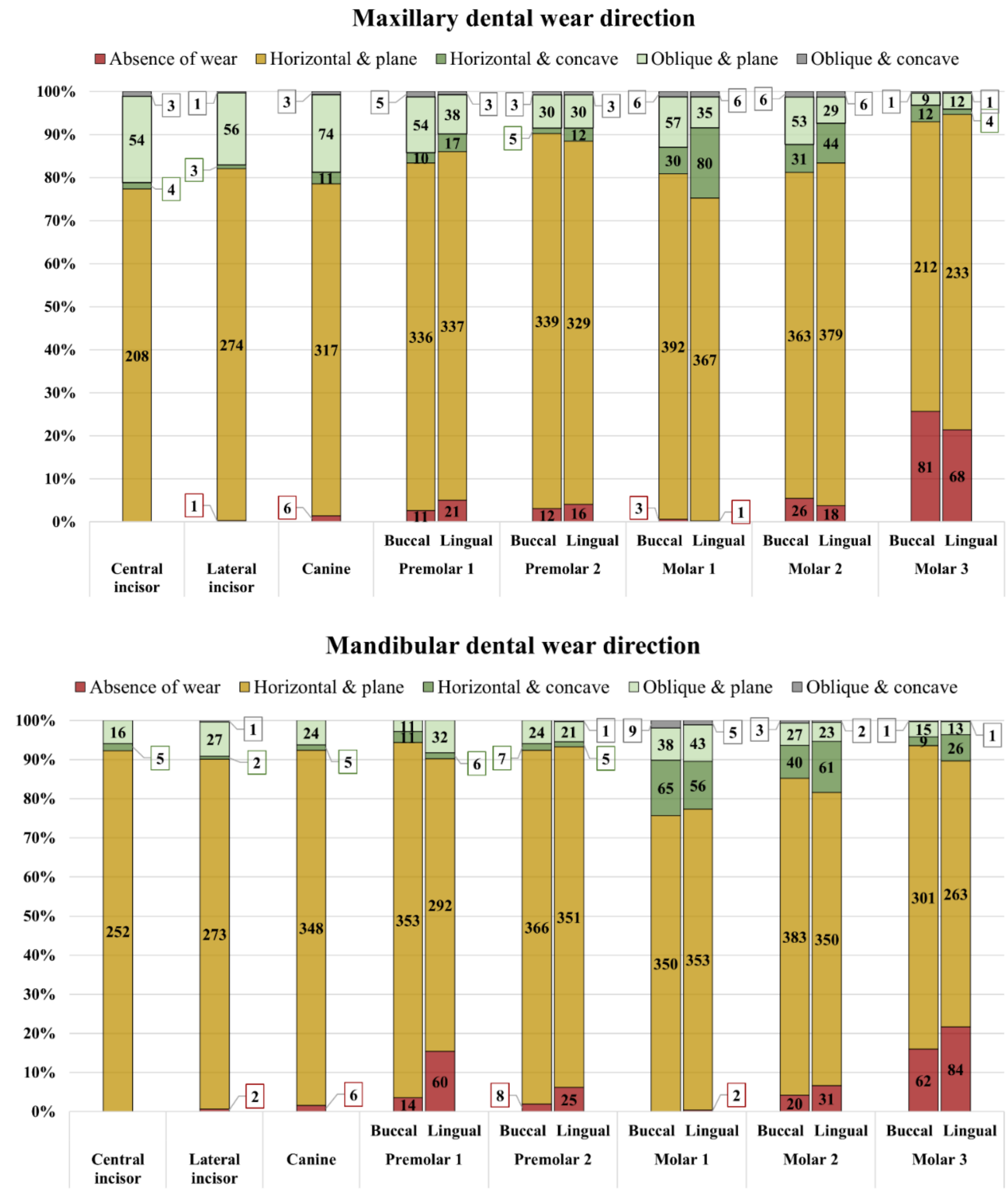


Figure 5.8: Frequency of dental wear direction for maxillae (top) and mandibles (bottom). The vertical axis presents relative frequencies expressed in percentage, and data labels in bars demonstrate frequency.

All teeth were most frequently horizontal and plane across all demographics. For sexed individuals, males had 55% (4670/8482) of scores, compared to females with 45% (3812/8482). The distribution of dental wear direction scores between jaws were insignificant; however, scores for sex were illustrated for both maxillae and mandibles to highlight notable differences in their relative frequencies between tooth types (Figure 5.9). Following horizontal and plane, oblique and plane was the subsequent common direction for maxillae, and for mandibles, it was horizontal and concave. Oblique and concave were the least represented stage for either sex, even ahead of the absence of wear. Horizontal and plane were almost equally represented across the dentition, although oblique and plane was marked in the anterior teeth for female maxillae, but on female mandibles, oblique and plane was notable on first premolars and first molars, and oblique and plane on the entire male dental arcade.

Similar to the distribution of dental wear quantity scores, dental wear direction was most frequently recorded on young/middle and middle/old adults (Figure 5.10). Young adults had 6% (337/5693) scores, young/middle-aged adults had 42% (2367/5693), middle-aged adults had 21% (1190/5693), middle/old-aged adults had 28% (1577/5693), and the fewest scores were for old-aged adults with 4% (222/5693). Differences between the distribution of direction scores for maxillae and mandibles were insignificant. Across all age groups, horizontal and plane was most frequently observed, followed by oblique and plane, except for young and young/middle-aged adults whose secondary most frequent direction was absence of wear. The most infrequent direction for old-aged adults was absence of wear and oblique and concave, both stages representing 1% of all old adult scores (3/222 for both stages). Although horizontal and plane represented the highest frequencies for all teeth and age categories, oblique and plane occurred subsequently for the canines across all age groups, and oblique and concave occurred on first and second molars across all age groups.

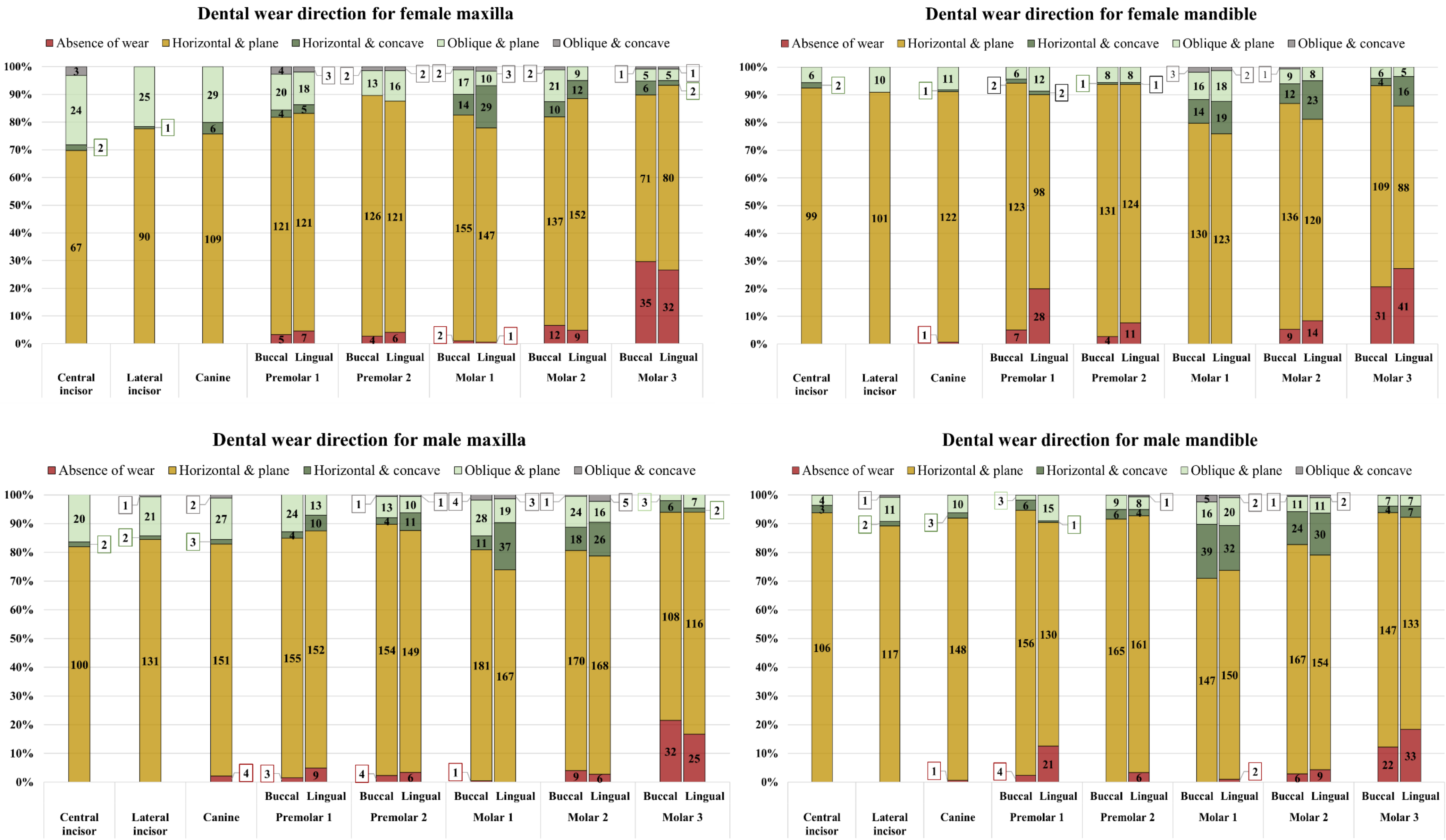


Figure 5.9: Frequency of dental wear direction between maxillae and mandibles for females (top) and males (bottom). The vertical axis presents relative frequencies expressed in percentage, and data labels in bars demonstrate frequency.

Figure 5.10: Frequency of dental wear direction for age-at-death categories. From top left to right: young adults, young/middle adults, middle adults, middle/old adults, and old adults (bottom). The vertical axis presents relative frequencies expressed in percentage, and data labels in bars demonstrate frequency.

Coastal individuals possessed 86% (8862/10253) of direction scores, compared to inland individuals with 14% (1391/10253), and the frequency for each tooth type is in Figure 5.11. Differences between the distribution of wear direction scores for maxillae and mandibles were insignificant. Horizontal and plane was the most frequently scored direction and had a relatively equal distribution across the dental arcade. Regarding subsequent patterns, horizontal and concave patterns were more frequent in the first and second molars for both spatial regions, particularly on the lingual cusps of all the posterior teeth. In coastal individuals, the second-most frequent direction was oblique and plane (8%; 719/8862); in inland individuals, it was horizontal and concave (10%; 145/1391).

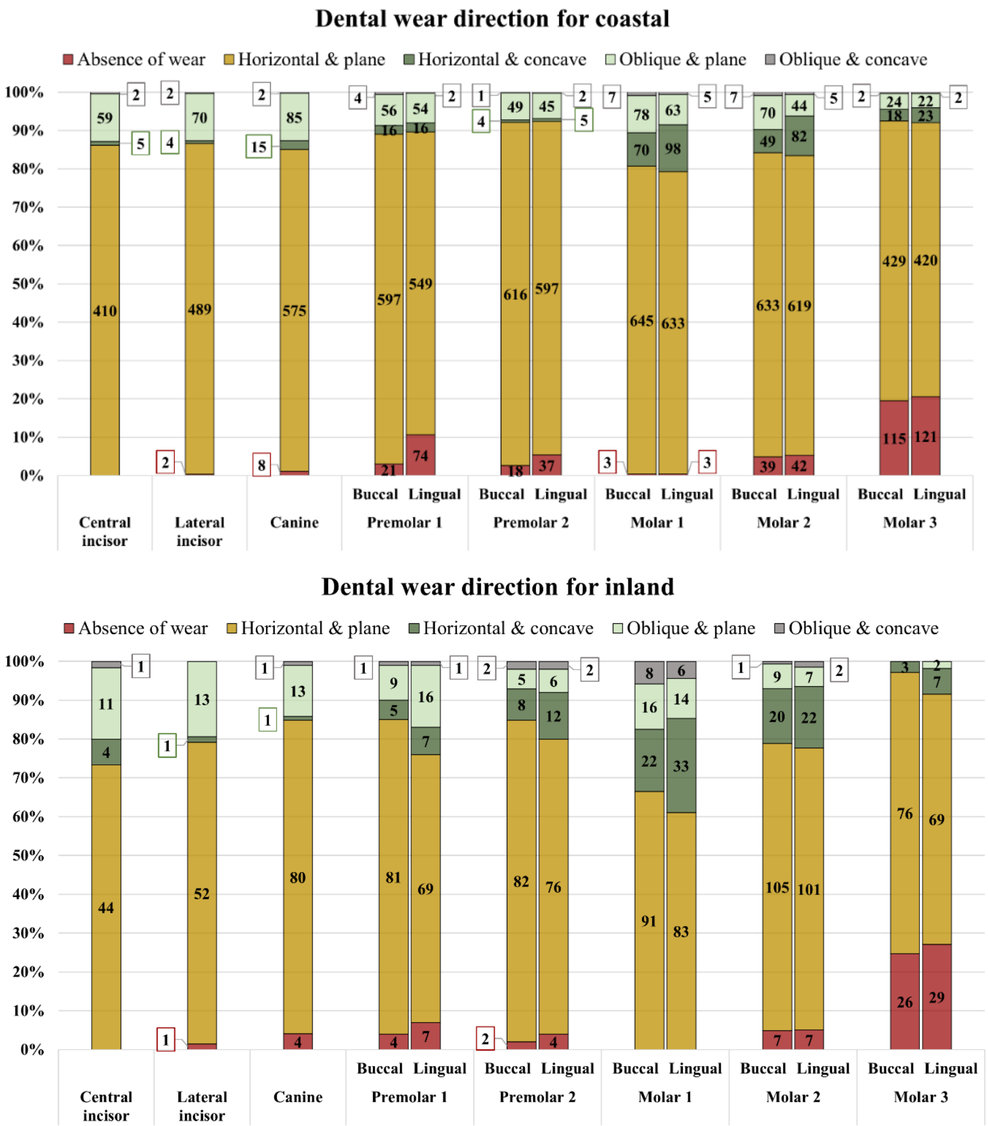
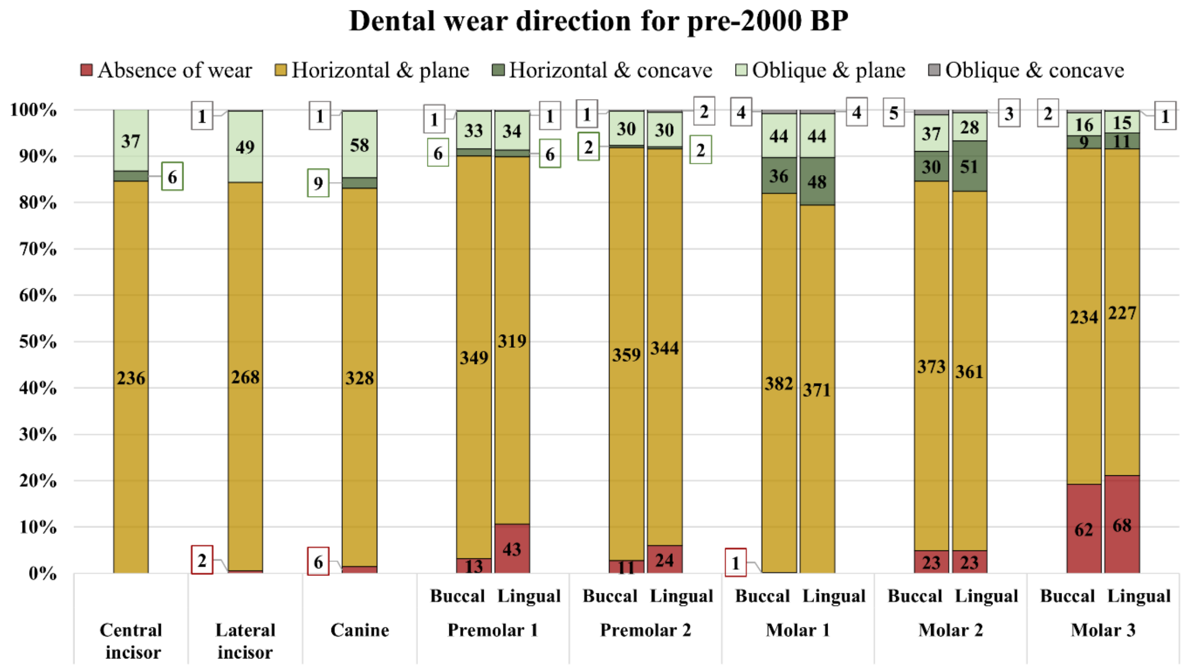


Figure 5.11: Frequency of dental wear direction for spatial regions of coastal (top) and inland (bottom). Relative frequency expressed in percentage were presented in the vertical axis and frequency was demonstrated in bars as data labels.

There were 59% (5124/8635) of scores recorded for pre-2000 BP, compared to 41% (2511/8635) of scores for post-2000 BP, and the frequency of stages for tooth types are in Figure 5.12. Differences between the distribution of wear direction scores for maxillae and mandibles were insignificant. Across the entire dental arcade, horizontal and plane was the most frequently observed direction score. Post-2000 BP demonstrated more overall concave direction scores than pre-2000 BP, which included horizontal and concave, and oblique and concave stages. Similarly, post-2000 BP had 7% (251/3511) total concave scores, compared to pre-2000, which had 5% (242/5124) total concave scores. Between temporal periods and within the realm of a concave direction for both horizontal and oblique angles, the first and second molars demonstrated the highest frequencies of a concave direction.

The middle Holocene represented 45% (3917/8635) of scores, followed by 41% (3511/8635) for the later Holocene and 14% (1207/8635) for the earlier Holocene (Figure 5.13). There was a significant relationship between the distributions of the variables for maxillae and mandibles, $\chi2(2, 8635) = 11.316$, p=0.003. The same observations were prevalent as reported for pre/post-2000 BP, where the later Holocene had a slightly higher prevalence of overall concave wear directions (7%; 251/3511), compared to the middle Holocene with 5% (188/3917) and the earlier Holocene with 5% (54/1207). In sum, higher overall concave direction for horizontal and oblique angles was seen most frequently on the first and second molars for all Holocene divisions, potentially due to abrasion.



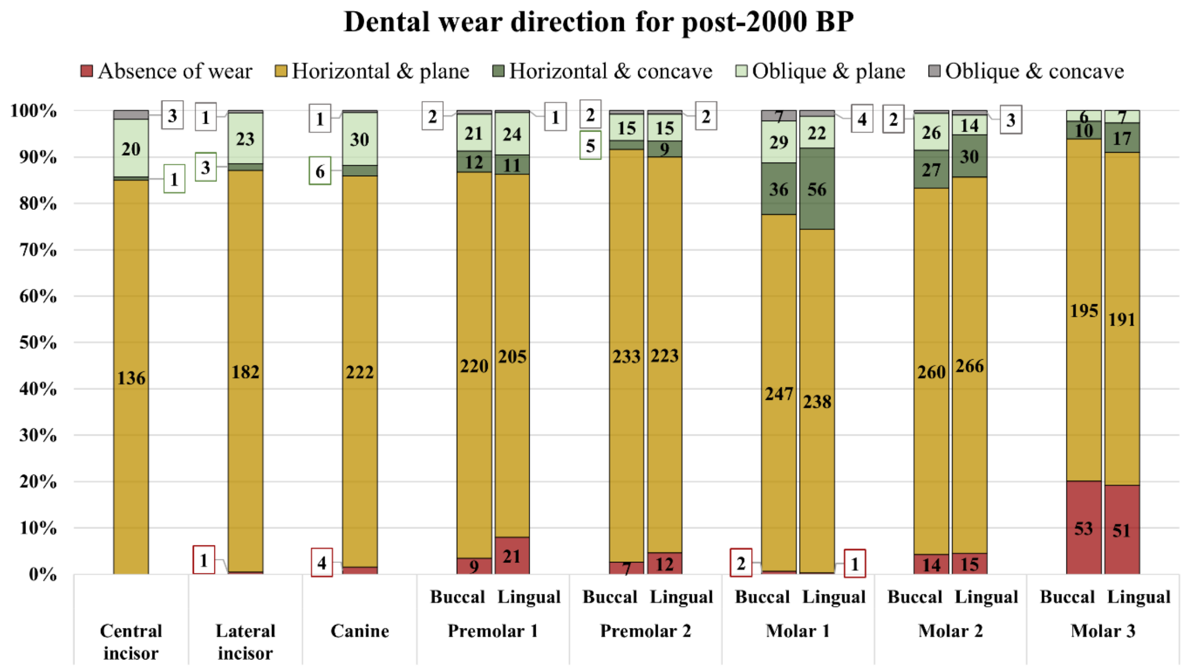


Figure 5.12: Frequency of dental wear direction for temporal periods of pre-2000 BP (top) and post-2000 BP (bottom). The vertical axis presents relative frequencies expressed in percentage, and data labels in bars demonstrate frequency.

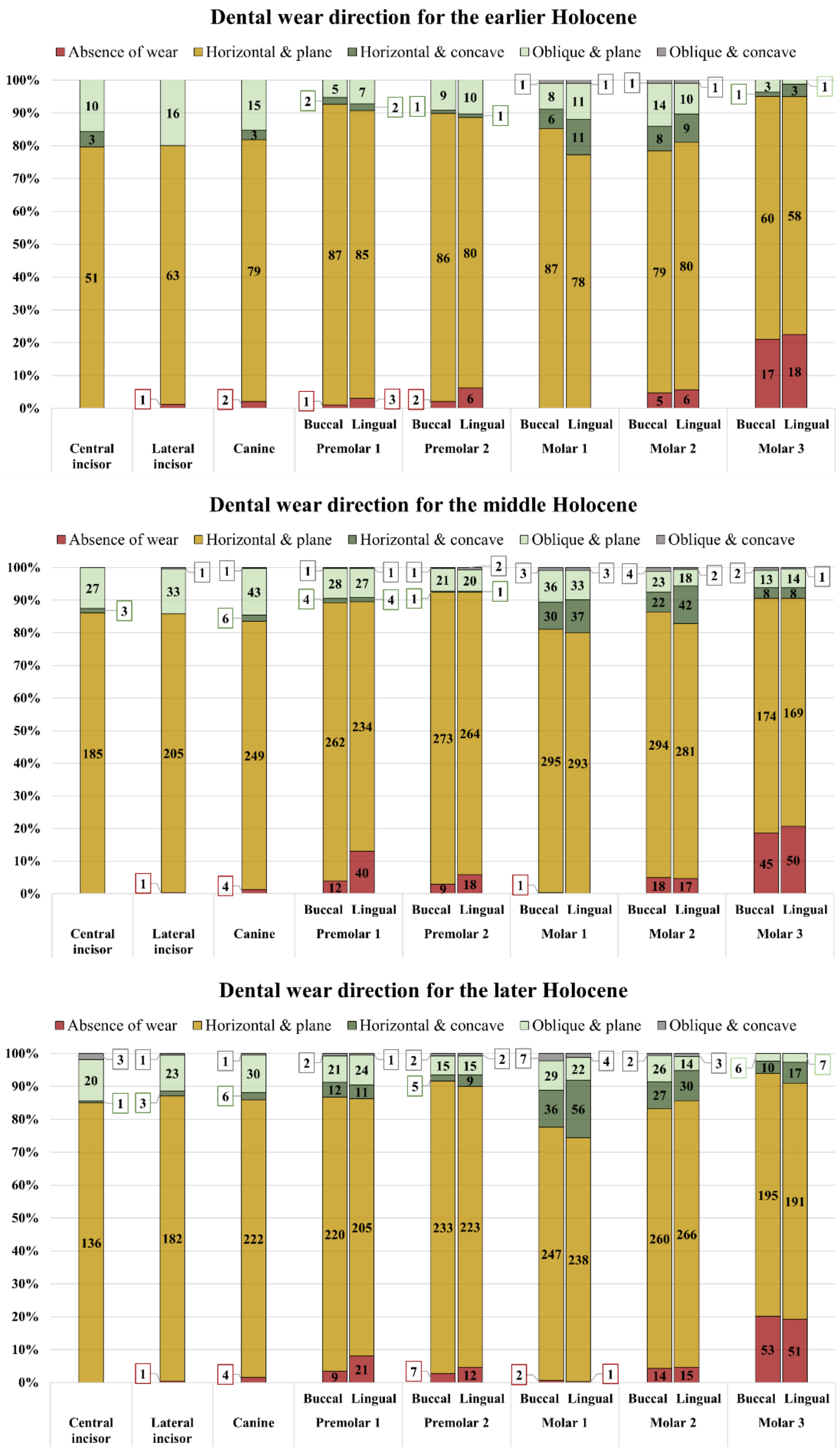


Figure 5.13: Frequency of dental wear direction for Holocene divisions of earlier (top), middle (middle), and later (bottom) Holocenes. The vertical axis presents relative frequencies expressed in percentage, and data labels in bars demonstrate frequency.

5.4.1 Multiple factors and their effect on wear direction

The effects of numerous factors, including dental arcade (maxilla and mandible), morphological tooth groups (anterior, premolar, posterior) and demographic variables were conducted for direction using multinomial regression models. Tooth types were collapsed into morphological tooth groups in early assessments to reduce the number of factors, considering initial models predicted horizontal and plane across all tooth types and cusp surfaces. Moreover, age was removed to reduce the number of factors, and absence of wear was replaced by horizontal and plane as the baseline category, which improved the model's fit (AIC=612.479). Model factors included collapsed teeth, dental arcade, sex, spatial and pre/post-2000 BP, and Table 5.12 presents significant results. Overall, anterior and premolar teeth had a reduced likelihood of horizontal and concave wear (anterior: OR=0.18, $p \leq 0.001$; premolar: OR=0.2, $p \leq 0.001$). Maxillae had greater odds for oblique and horizontal (OR=1.8; $p \leq 0.001$) and oblique and concave wear (OR=1.9, $p=0.03$). Coastal individuals had reduced odds of oblique and plane (OR=0.69, $p=0.03$) and oblique and concave (OR=0.22; $p \leq 0.001$) wear. Pre-2000 BP individuals were likelier for oblique and plane wear (OR=1.3; $p=0.002$).

Table 5.12: Significant multinomial regression results on effects of factors between all dental wear direction stages. OR=Odds ratio; †temporal effects were appreciable for the earlier and middle Holocene in an additional model, but the current model only included pre/post-2000 BP to reduce the number of factors. The reference category was horizontal and plane.

Direction	Factor	Estimate	OR	Std. Error	*P*-value	95% Confidence Interval for OR	
						Lower	Upper
Horizontal and concave	**Anterior**	-1.717	0.18	0.219	<.001	0.117	0.276
	Premolar	-1.6	0.202	0.165	<.001	0.146	0.279
	Coastal	-0.62	0.538	0.137	<.001	0.411	0.704
Oblique and plane	**Anterior**	0.573	1.773	0.105	<.001	1.443	2.179
	Female	0.286	1.331	0.088	0.001	1.12	1.581
	Coastal	-0.376	0.686	0.128	0.003	0.534	0.882
	Pre-2000†	0.286	1.331	0.094	0.002	1.107	1.6
	Maxilla	0.59	1.804	0.09	<.001	1.512	2.152
Oblique and concave	**Female**	0.669	1.951	0.303	0.027	1.078	3.533
	Coastal	-1.494	0.224	0.327	<.001	0.118	0.426
	Maxilla	0.657	1.93	0.308	0.033	1.055	3.53

Due to appreciable results for the dental arcade, subsequent models were performed by separating the file between maxillae and mandibles (Tables 5.13 and 5.14, respectively) while maintaining the same factors to assess any effects of factors between jaws. The final AIC for the maxilla model was 300.936 and 320.052 for mandibles. Maxillary anterior teeth had considerably greater odds for oblique and plane wear (OR=2.5; $p \leq 0.001$), as female maxillae had greater odds for both oblique and plane (OR=1.4; *p*=0.003) and oblique and concave (OR=2.9; *p*=0.005) wear. Coastal mandibles demonstrated reduced odds in oblique and plane wear (OR=0.55; *p*=0.003), and pre-2000 BP mandibles had greater odds in oblique and plane wear (OR=1.6; *p*=0.003). The entire dental arcade for coastal individuals had reduced odds for oblique and concave wear (maxillae: OR=0.2, $p \leq 0.001$; mandibles: OR=0.1; *p*=0.002).

Table 5.13: Significant results of multinomial regression for maxillae against multiple factors between all dental wear direction stages. OR=Odds ratio. The reference category was horizontal and plane.

Direction: Maxilla	**Factor**	**Estimate**	**OR**	**Std. Error**	***P*-value**	**95% Confidence Interval for OR**	
						Lower	***Upper***
Horizontal and plane	**Anterior**	-1.245	0.288	0.277	<.001	0.167	0.495
	Premolar	-1.234	0.291	0.215	<.001	0.191	0.443
	Coastal	-0.662	0.516	0.193	<.001	0.353	0.753
Oblique and plane	**Anterior**	0.902	2.464	0.132	<.001	1.902	3.191
	Female	0.331	1.393	0.111	0.003	1.12	1.732
Oblique and concave	**Female**	1.07	2.915	0.382	0.005	1.378	6.167
	Coastal	-1.398	0.247	0.401	<.001	0.112	0.542

Table 5.14: Significant results of multinomial regression for mandibles against multiple factors between all dental wear direction stages. OR=Odds ratio. The reference category was horizontal and plane.

Direction: Mandible	**Factors**	**Estimate**	**OR**	**Std. Error**	***P*-value**	**95% Confidence Interval for OR**	
						Lower	***Upper***
Horizontal and concave	**Anterior**	-2.263	0.104	0.365	<.001	0.051	0.213
	Premolar	-2.025	0.132	0.265	<.001	0.079	0.222
	Coastal	-0.6	0.549	0.197	0.002	0.373	0.807
Oblique and plane	**Coastal**	-0.602	0.548	0.206	0.003	0.366	0.82
	Pre-2000	0.471	1.601	0.158	0.003	1.174	2.184
Oblique and concave	**Premolar**	-2.269	0.103	1.037	0.029	0.014	0.789
	Coastal	-1.782	0.168	0.578	0.002	0.054	0.522

5.5 Non-masticatory wear

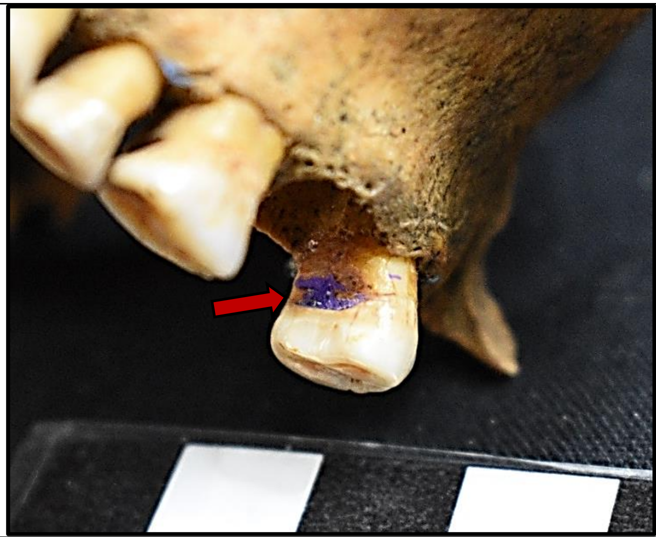
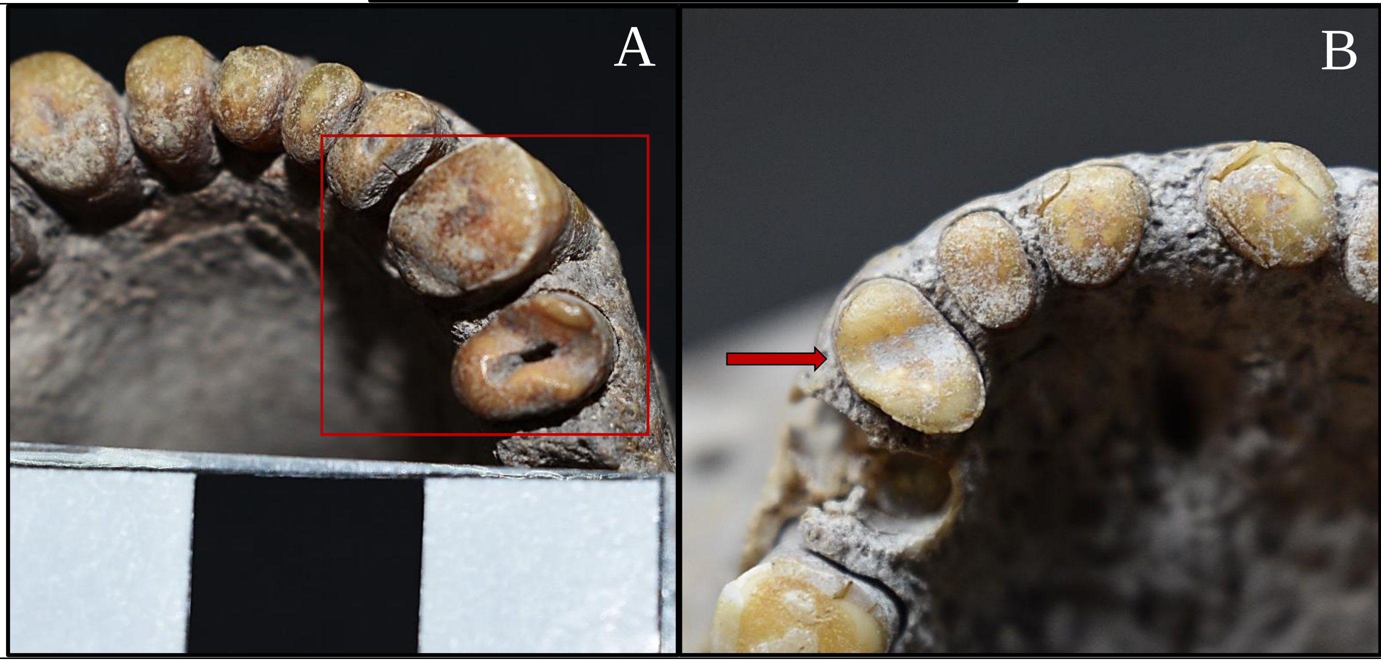
Due to the variety of non-masticatory wear regarding shape, size, orientation and location, characteristics were recorded using physical descriptions (Table 5.15). There were 6% (22/369) of individuals with marked non-masticatory wear in the form of tool grooves, notches or localised abrasion. Of the 22 individuals, 77% (17/22) had a sex and 23% (5/22) were indeterminate. Most of the sexed individuals were female (71%, 12/17) compared to males (29%, 5/17). A total of 77% (17/22) had age estimates, and 23% (5/22) were indeterminate. Ages were represented by one young adult, five young/middle-aged adults, four middle-adults, five middle/old-aged adults and two old-aged adults. Spatially, 95% (21/22) had a provenance, and one individual had unknown provenance; 76% were coastal individuals (16/21), and 24% (5/21) were inland individuals. Temporally, 86% (19/22) were dated, and 14% (3/22) had unknown dates. Pre-2000 BP represented 42% (8/19) and 58% (11/19), dated to post-2000 BP. Furthermore, 11% (2/19) dated to the earlier Holocene, 32% (6/19) to the middle Holocene, and 58% (11/19) to the later Holocene.

Table 5.15: Photographic examples of select individuals with characteristic types of non-masticatory wear found in this study.

Characteristics	Photographic examples
Isolated abrasion Figures A and B demonstrate anterior localised abrasion on an individual (A414), as visible on the mesial side of the upper right central incisor (1.1). The remaining maxilla was reconstructed, and the neighbouring teeth were unavailable.	 
Anterior notching/grooves Figure A (SAM-AP 1142), B (SAM-AP 6348b) and C (UCT 158) (continued on next page) demonstrate examples of notching or grooves, predominantly on the anterior teeth.	 

	
Isolated abrasion and grooves on multiple teeth Figure A (SAM-AP 1878) demonstrates localised abrasion on the upper right premolars (1.4 and 1.5). Figure B (UCT 54) presents several examples of localised abrasion and notching throughout the dentition.	 

Labial/buccal localised abrasion Figure A (UCT 66) demonstrates an example of wearing that occurs on the labial side of the mandibular anterior teeth. Figures B and C (UCT 391) demonstrate similar characteristics, although in a more extreme case, on both the maxilla and mandible.	

Interproximal grooves An individual (UCT 218b) demonstrated interproximal grooves between a few teeth. The example presented is on the maxillary left third molar (2.8).	
Fibrous grooves running laterally The individual (UCT 429) exhibits fibrous grooves that run laterally across multiple teeth. The grooves in Figure A run along the right mandibular canine (4.3) and first premolar (4.4). Figure B exhibits the groove on the right maxillary canine (1.3).	

5.6 Wear quantity discussion

Wear patterns on tooth types generally followed dental eruption times, and partial dentine exposure was the most frequent quantity score (40%, 4042/10209), followed by complete dentine and pulpal exposure. Past sAHGH and global HGH studies expect heavy or rapid occlusal wear due to the diet (Pfeiffer, 2007; Górka, Romero & Pérez-Pérez, 2015; Littleton, 2017; Gibbon & Davies, 2020). Depending on the type of food consumed, mandibular motion slightly adjusts and influences varying dental wear patterns. The rapid wearing of HGH dentition is caused by wider mandibular movement, resulting in 'rotary' mastication from tough and fibrous foods (Górka, 2016). This type of wear results in marked and even wear across all teeth and cusps (Smith, 1984). Foods with tougher consistencies require high masticatory loads and prolonged chewing (Mays, 2015) and examples can include foods such as unprocessed or dried meats, seeds, corms, and tubers (Górka, 2016; Pfeiffer et al., 2020). The HGH chewing motion and wear pattern is critical to note since observations of uneven occlusal wear suggest abrasive contamination, as abrasion is not confined to anatomical functions and can inconsistently affect any area of the crown (Kaidonis, 2008).

Measurements of 'heavy wear' vary across sAHGH studies, where methods are either not defined (Morris, Thackeray & Thackeray, 1987; Jerardino et al., 1992), few select teeth are assessed (Van Reenen, 1964), or the study included one side of the dentition rather than the complete dentition (Sealy & van der Merwe, 1988; Morris, 1992a; Sealy et al., 1992; Van Reenen, 1992; Constant & Grine, 2001; Pfeiffer et al., 2020). There are also methodological issues from sAHGH studies using various dental wear scoring systems that complicate comparisons, as scoring systems have included Broca (1879), Molnar (1971), Brothwell (1981), Smith (1984), unknown standards, and in the case of this thesis, Brabant (1966). Morris (1992a) attempted to mitigate the use of different methods by compiling dental wear data from certain studies (Drennan, 1929; Van Reenen, 1964) and adjusting the scores to use the same four-stage system by Brothwell (1981), which Sealy and colleagues (1992) also employed in their study. As all the employed dental wear systems in past studies had published visual guides, comparing studies is facilitated, further supported in this thesis by introducing a visual guide for the Brabant index. Mean wear quantity indices from this and past sAHGH studies and select contact period populations with mixed HGH and farm-based lifeways were compiled in Table 5.4. The mean wear quantity results from the 369 individuals scored in this thesis averaged 2.3, and as past research reported, sAHGH dental wear quantity maintained an average of ~2 or partial dentine exposure as demonstrated by the compiled mean wear indices, which suggests sAHGH demonstrate moderate wearing when assessed holistically. Although one can argue that this average of partial dentine exposure does not define heavy wear in the form of frequent pulpal exposure, most of the samples were skewed towards young/middle or middle-aged adults and would exhibit moderate wear. Although this thesis did not include a quantitative estimate for wear rates, a study by Gilmore and Grote (2012) estimated the rate of wear on sAHGH teeth and compared the data to eight other global HGH populations using the Miles (1963b,a) method. Out of nine total populations, the authors reported that the fastest wear rates occurred first in Algerian HGH groups associated with the Iberomaurusian material culture at Afalou but were immediately followed by sAHGH populations. Based on these results, sAHGH teeth wear down faster than most global HGH groups, and if an individual lived long enough and this sample was represented by more old-aged adults, the teeth would sooner present more instances of pulpal exposure and a higher mean.

The anterior teeth wore ahead of the posterior teeth, demonstrated by greater odds (OR= 18, $p \leq 0.001$), and anterior mean wear was 2.6, compared to the posterior teeth mean of 2.1. Both sAHGH dental studies (Van Reenen, 1966, 1992; Morris, 1992a; Botha & Steyn, 2015; Gibbon & Davies, 2020) and global HGH studies (Molnar, 1971; Smith, 1984; Deter, 2009; Clement & Hillson, 2012; Littleton et al., 2013; Littleton, 2017) have reported heavier wear in the anterior teeth. Several factors contribute to advanced anterior wear, including eruption times. The permanent maxillary dentition typically erupts in phases: the first molar, central and lateral incisors (5–8 years); then first premolars, canines, second premolars and second molars (9.5-12.5 years); and lastly, the third molars (>15-18 years). Mandibular teeth have a similar eruption order, albeit the canines may erupt ahead of the premolars (Esan & Schepartz, 2018). Although the incisors erupt earlier than most teeth, the anterior dentition also includes canine teeth, which erupt several years later. Based on this information, alternative explanations for heavy anterior wear in sAHGH dentition may be due to consuming certain foods, contamination of exogenous environmental particles, but most likely, the non-alimentary use of the anterior teeth. Using teeth as tools overloads the anterior dentition, resulting in a higher localised rate of wear (Clement & Hillson, 2013). Interestingly, the maxillary premolar teeth also exhibited greater odds (Upper PM1: OR=3.7, $p \leq 0.001$; Upper PM2: OR=2.4, $p \leq 0.001$) for increasing wear quantity. Both the anterior teeth and the premolars may have been used more frequently for a combination of tasks such as nut breaking (Bonfiglioli et al., 2004), plant and hide stripping, softening skins, and rope making (Van Reenen, 1992), whereas the cheek muscles would have protected the molars and would have been used infrequently for tasks other than mastication (Clement & Hillson, 2012) or nut breaking, which would likely present as microchipping (Van Reenen, 1992). Although the first molars consistently demonstrated greater odds for advanced wear, this was likely associated with their earlier eruption. Additionally, the molar teeth often wear ahead of their counterparts in numerous populations due to their role in grinding food (Mays, 2015). Between upper and lower teeth, the anterior maxillary teeth had reduced odds in multiple models for advanced wear ahead of the anterior mandibular teeth. These odds were potentially due to the smaller mandibular tooth morphology (Górka, 2016), and they may appear to have worn marginally faster when directly compared to their larger, maxillary counterparts.

Interindividual variation is a principal challenge for dental wear analyses (Gilmore & Grote, 2012); however, the rapid wear rate and similar results across past studies demonstrate homogeneous group (Kaidonis, 2008) regarding behaviours contributing to sAHGH dental wear. As demonstrated by these results, a systematic analysis of dental wear for a population can provide an overall understanding of wear quantity patterns for sAHGH dentition across time and space.

5.6.1 Buccal and lingual posterior tooth wear

Mean wear quantity between buccal and lingual surfaces were insignificant and similar, where buccal surfaces presented a mean of 2.2 and lingual surfaces reported a mean of 2.1, but wear patterns differed depending on the stage of dentine exposure. A standard development of wear in molars exhibits faster wear on the maxillary lingual surface than the buccal surface, and the converse in mandibular molars, buccal ahead of lingual (Smith, 1984). This expectation was reflected, albeit with an exception on the maxilla, where the results only demonstrated this pattern with advanced wear in the form of complete dentine or pulpal exposure. Conversely, data showed the opposite for teeth with enamel polishing or partial dentine exposure; therefore, dental wear scores before complete dentine exposure exhibited wearing first on the maxillary buccal and mandibular lingual surfaces. Once the dentine was exposed, the lingual side of multi-cuspid teeth wore rapidly. Resulting rapid lingual wearing may indicate an increase in transverse mandibular movement from reliance on fibrous food types, as reported using three-dimensional crown models on two sAHGH individuals by Fiorenza and colleagues (2011) and supported by a microwear study confirming a plant-reliant sAHGH diet (El-Zaatari, 2010). If there were a reliance on meat products which are tough but pliant, Fiorenza and colleagues

(2011) reported that the buccal side would exhibit larger facets, which would have likely exhibited rapidly increasing dentine exposure on the buccal side as opposed to the lingual in this study.

Dental wear research has often excluded the premolars from analyses due to morphological complexity in shape and size, occasionally and inconsistently affecting their wear rate (Sperber, 2017). In this thesis, premolar wear patterns were relatively similar to the molars between cusps, except on the lingual side of the mandibular premolars. The lingual side wore slower than the buccal side, as demonstrated through high frequencies of enamel polishing compared to the buccal side exhibiting higher incidence rates for partial dentine exposure. This may be due to mandibular premolars having three cusps, making buccal cusps far more likely to withstand the worst of masticatory loads than lingual cusps (Górka, 2016). Moreover, the crown curves lingually, which protrudes the buccal cusp instead of maintaining a straight form, as apparent in maxillary premolars, which makes both maxillary premolar cusps equally in contact with opposing surfaces (Scheid & Weiss, 2012). Although the lingual side maintained a polished state for longer, the buccal occlusal surface received the brunt of masticatory load ahead of its counterpart, hence the comparatively rapid development of buccal dentine exposure. Statistically, average wear scores of buccal and lingual sides were insignificant; therefore, multi-cuspid teeth on this sample followed a steady rate of wear even when the cusps were independently scored. In future studies, any deviations from the standard rate of wear between cusps can elucidate insights into extrinsic and intrinsic factors on a case-by-case basis.

5.7 Wear direction discussion

Horizontal and plane wear occurred most frequently (80%, 8321/10375), which met expectations. Several sAHGH studies have acknowledged an overall flat wear direction due to plant-based dietary components (Morris, 1992a; Van Reenen, 1992; Pfeiffer & Sealy, 2006; Gibbon & Davies, 2020; Pfeiffer et al., 2020), although flat wear is also ubiquitous for HGH teeth when consuming fibrous, unprocessed foods and has been widely considered a global phenomenon (Molnar, 1971; Molnar et al., 1972; Smith, 1984; Calcagno & Gibson, 1991; Kieser et al., 2001; Kaifu et al., 2003; Deter, 2009; Forshaw, 2015; Orton et al., 2015; Fiorenza et al., 2018). The initial regression models with 'absence of wear' as the reference category consistently predicted horizontal and plane above all other stages, to the extent that 'horizontal and plane' was adjusted as the reference category for further analyses, because otherwise the regression failed to predict meaningful results for other variables. Flatter occlusal wear is associated with a wider lateral excursion of the mandible in response to the mastication of tough, fibrous foods (Smith, 1984). The biological phenomena of flat wear are also directly related to human evolution, where the morphology and placement of the teeth are designed to endure continuous wear eventually resulting in flat, symmetrical wearing (Kaifu et al., 2003). As such, oblique or concave wear patterns are anomalous to the process of dental wear for human dentition, where indications of changing wear direction have been most notable upon the introduction of agriculture (Grimoud & Gibbon, 2017), associated with human manipulation of the environment in the form of plant domestication and refined food processing. With the introduction of softer foods in industrialised society, chewing time is exponentially decreased, significantly reducing tooth-on-tooth contact (Watson, 2008). The dentition of contemporary societies wear down even slower and wear direction does not drastically change due to slower rates of wear and further affected by the introduction of modern dentistry (Lee et al., 2012).

The results demonstrated that anterior teeth were almost two times more likely (OR=1.7, $p \leq 0.001$) to exhibit oblique and plane wear compared to the molars; however, anterior teeth still demonstrated horizontal and plane wear most frequently, which aligns with HGH expectations (Kaifu et al., 2003) and an eventual 'edge-to-edge' bite in sAHGH teeth as reported by Van Reenen (1964, 1992). Agriculturalist populations tend to demonstrate anterior oblique wearing more often across the dentition (Grimoud & Gibbon, 2017). Yet, tool use may increase the angle of oblique wear in HGH teeth, gradually developing over time as the angle changes how the upper and lower teeth interact (Smith, 1984). Both anterior and premolar teeth exhibited reduced odds (anterior: OR=0.18, $p \leq 0.001$; premolar: OR=0.2, $p \leq 0.001$) for horizontal and concave wear compared to the molars, which suggested the molars would be more likely to exhibit concave wear, likely due to abrasion from environmental contaminants during mastication (Fiorenza et al., 2018). Van Reenen (1992) also reported sAHGH concave wearing, likely due to abrasion, although where the concave wear is typical in the mandible, this thesis reported equally appreciable effects for either jaw. Morris (1992a) also discussed that incisors tend to round ahead of the posterior teeth. Where this thesis found occasional concave wearing in the anterior teeth in this thesis, the statistical results did not suggest meaningful results. It may be that Morris's (1992a) discussion of concave wearing implied anterior rounding from tool use, to which there were several examples of anterior notching and grooving, as demonstrated in Table 5.15 and discussed in detail later in this chapter (see Section 5.8).

Fiorenza and colleagues (2018) assessed 34 Palaeolithic HGH individuals from seven localities (Croatia, France, Czech Republic, Israel, Romania, Italy, and Russia) and found intergroup variation with steeper wear angles between Palaeolithic hunter-gatherer groups, suggesting they exploited different resources. The authors iterated that other factors must be considered when observing changing wear directions, including environmental abrasion, food processing techniques, and interindividual behaviour. Therefore, when the study sample in this thesis did not exhibit horizontal and plane wear, concave wearing in the posterior teeth was likely multifactorial, possibly due to abrasion, as the southern African environment was sandy along the coast and within the arid interior (Wessels et al., 2011), and instances of oblique wearing in the anterior teeth was due to tool use (Milner & Larsen, 1991). Cooking foods and grinding grains reduces food toughness (Fiorenza et al., 2018) and has generally been correlated with heavy oblique wear on the entire dentition (Smith, 1984). However, there is little archaeological evidence of intensive food processing techniques for precontact sAHGH individuals, apart from the increased prevalence of grindstones around the later Holocene (Lombard et al., 2012) and spouted vessels for storing or cooking fat or milk (Copley et al., 2004). Typically, food processing techniques are noteworthy in studies on agricultural (Eshed, Gopher & Hershkovitz, 2006; Gibbon & Grimoud, 2014) and contemporary populations (Lee et al., 2012; Fiorenza et al., 2018) and occasionally for contemporary hunter-gatherers (Pontzer & Wood, 2021). Therefore, the results of more frequent horizontal concave wear than oblique and concave support the findings that the sAHGH diet was predominantly plant-based, resulting in a horizontal angle from wide lateral excursion of mandibular movement from consuming tough plants such as corms and tubers, for example, along with an occasional concave direction being affected by using teeth as tools and environmental abrasion. If the presence of refined food processing were notable in sAHGH behaviour, the dentition would have demonstrated a greater likelihood of symmetrical oblique wearing across all present teeth and not predominantly in the anterior teeth.

5.7.1 Buccal and lingual posterior tooth wear

As wear progresses in the posterior teeth, the mandibular molars demonstrate steeper wear from lingual to buccal cusps, and conversely, the maxillary molars demonstrate steeper wear from buccal to lingual. These patterns develop gradually following the sequence of eruption times, resulting in a reversed curve of Monson or a helicoidal occlusal plane (Osborn, 1982; Watson, 2008). This pattern tends to present itself in contemporary populations as reduced mastication decreases the lateral movements of the mandible and increases the contact area between cusps resulting in steeper angles of wear (Hall, 1976; Osborn, 1982). In a population that maintained a diet predominating fibrous plant-based foods, along with terrestrial and marine protein with minimal processing (Sealy, 1984; El-Zaatari, 2010), the axis slope would be expected to be flatter and more even between cusps (Smith, 1984). These results met these expectations, demonstrated through significant odds for horizontal and plane wear and across frequencies illustrated for buccal and lingual cusps. Unlike wear quantity, the buccal and lingual sides between posterior teeth were relatively equal. Still, there was an exception, although not profound, of which the buccal side of the posterior maxillary teeth was more frequently oblique and plane, whereas the lingual sides were more horizontal and concave. This pattern may correlate with the location and role of the posterior teeth during the intercuspal phase of the chewing cycle and the gradually changing angle of the occlusal plane during early and moderate stages of wear quantity. This process may result in slight variance on the buccal half, where wear concentrates first until it flattens out, with the added contamination of abrasive particles that encouraged inconsistent developments of concave wearing on some occlusal surfaces (Kay & Hiiemae, 1974; Mair et al., 1996).

5.8 Non-masticatory wear discussion

There were 22 individuals with either prevalent tool-use grooves on one or several teeth or isolated wearing (localised abrasion) that stood out due to characteristic variation from the remaining dentition (Table 5.15). Since dentition functions as a unit, variations on isolated teeth are likely related to using teeth as tools (Molnar, 1971). Although the sample size for non-masticatory wear was small, of sexed individuals with non-masticatory wear, most were female (71%, 12/17), and males only represented a few cases (29%, 5/17). These results for sex aligned with gender-based labour as reported in archaeological studies (Botha & Steyn, 2015; Gibbon & Davies, 2020) and ethnographic observations that females would have been responsible for some household and tool-related chores such as plant and hide stripping using the teeth (Lee, 1979; Tanaka, 1980). The sample size for non-masticatory wearing was too small and similarly distributed to elucidate age. Moreover, the gradual increase of wear with age would complicate these observations, considering older ages may underrepresent tool markings due to the increasing rate of dental wearing and AMTL. Temporally, this study exhibited 58% of accidental wearing in post-2000 BP (11/19), whereas 42% occurred in pre-2000 BP (8/19). As previously mentioned, this may be due to new tool industries in post-2000 BP (Copley et al., 2004), which may have changed how the teeth were used as tools. Although the sample distribution remains similar between periods in such a small sample, and sample distribution bias must also be considered.

The majority of tooth tool markings were 'grooved' or 'notched' in shape on anterior teeth, running transversally across isolated teeth, or isolated abrasion. All of these characteristics have been widespread in global literature (Larsen, 1985; Brown & Molnar, 1990; Milner & Larsen, 1991; Alt & Pichler, 1998; Bonfiglioli et al., 2004; Eshed, Gopher & Hershkovitz, 2006; Erdal, 2008; Hylander, 2011; Burnett & Irish, 2017) and thus may correspond with several general, occupational tasks or parafunctional habits. Typically, pronounced and rounded wear on the anterior teeth occurs in HGH individuals who use the teeth as a third hand, whereas chipping has been a more prevalent indicator of occupational tasks in agricultural groups (Scott & Winn, 2011). This study sample demonstrated examples that, based on past research, may include activities such as basket making (Larsen, 1985), thread wetting (Erdal, 2008), sinew stripping (Brown & Molnar, 1990), wood shaping (Hylander, 2011), seed cracking (Hattab & Yassin, 2000), leather making (Bonfiglioli et al., 2004), and holding tools between the teeth (Alt & Pichler, 1998; Bonfiglioli et al., 2004), of which these activities for sAHGH individuals contributed to hut, clothing and bow and digging stick making as reported in ethnographic records (Lee, 1979). In the two individuals demonstrating transversal grooves, the possible occupational task would include processing plant fibres, basketry or cordage by running thread or sinew repeatedly through the teeth in a lateral direction (Larsen, 1985; Alt & Pichler, 1998; Eshed, Gopher & Hershkovitz, 2006; Erdal, 2008). Moreover, localised abrasion and notching also occur from oral habits such as nail biting and bruxism (Hattab & Yassin, 2000; Lee et al., 2012; Burnett, 2016). In more recent populations, similarly shaped rounded grooves in anterior teeth often correlate with pipe smoking (Alt & Pichler, 1998). However, this habit was irrelevant in this sample considering pipes only began production and global distribution in the 16th century (Kvaal & Derry, 1996), and precontact sAHGH individuals would not yet have had access to these items. Isolated wearing may have been due to leather and hide making or stripping, where the textile runs across an entire surface of a tooth (Milner & Larsen, 1991).

An individual (UCT 218b) whose data did not exhibit outward indications of CEJ demineralisation exhibited non-cariogenic, circular interproximal grooves on both the right and left sides of the maxilla. The mandible was not available to assess. Out of all individuals with non-masticatory characteristics, this individual was the only person dating to the earlier Holocene. The grooves also indicated possible habitual modification instead of generalised occupational modifications. These cylindrically-shaped interproximal grooves along the dentine-enamel junction have been discussed in a variety of archaeological populations and correlate with teeth cleaning, related to the habitual use of dental or toothpicks, using bone, wood, sinew, or strands of grass to clean between the teeth (Frayer & Russell, 1987; Formicola, 1988; Lukacs & Pastor, 1988; Alt & Pichler, 1998; Turner II & Cacciatore, 1998; Ungar et al., 2001; Bonfiglioli et al., 2004; Lozano et al., 2013; Oxilia et al., 2015; Ricci et al., 2016). Studies suggest using a tool for interproximal tooth regions for therapeutic and inflammation alleviation, and removal of impacted food, or idiopathic habits (Brown & Molnar, 1990; Turner II & Cacciatore, 1998; Bonfiglioli et al., 2004). Lukacs and Pastor (1988) have also suggested the action of sucking saliva through these spaces between teeth. Figure 5.14 exhibits the example from this study, where inserting a 'toothpick' prop demonstrates the action of repeatedly holding or moving a small cylindrically shaped object between the interproximal surface of the teeth. Interestingly, manual dental pathology intervention in precontact groups has been more complex than dental picking, where Oxilia and colleagues (2015) used SEM analyses to report additional attempts at dental cleaning of carious lesions in an individual from Italy, as well as similar efforts in another study with the added element of applying organic bitumen fillings, represented by nine Neolithic individuals from Pakistan (Oxilia et al., 2017). Therefore, precontact groups demonstrated examples of intentional responses to dental discomfort and it is likely in sAHGH behaviour, as picking the teeth with a tool is reported as far back as in hominin teeth (Ungar et al., 2001; Lozano et al., 2013) and is not just a contemporary behaviour.

In this individual, a neighbouring tooth was non-vital, as visible in Figure 5.14, demonstrating pulpal necrosis and an associated infectious lesion. Bonfiglioli and colleagues (2004) reported that similarly grooved teeth were often associated with dental decay in the same or adjacent teeth, which suggested that using an interproximal tool alleviated inflammation. As such, I suggest that in this sample, interproximal grooves may have also been the result of therapeutic action from gum irritation due to the neighbouring teeth demonstrating advanced dental decay, which some oral discomfort would have followed. The location of the interproximal grooves on the posterior teeth also suggest therapeutic or habitual probing, as Lukacs and Pastor (1988) suggested interproximal grooves on the anterior teeth are likely occupationally induced. Notably, these observations are drawn from macroscopic data, and a microwear assessment of the grooves may shed light on the direction of the microscopic scratches (Formicola, 1988; Oxilia et al., 2015) to confirm whether the markings were due to a repeated inserting/removing motion from a vestibular insertion point, or inconsistent markings instead suggesting alternative means, such as running thin fibres between the teeth as an occupational task. This is the first known report of dental picking in precontact sAHGH teeth,

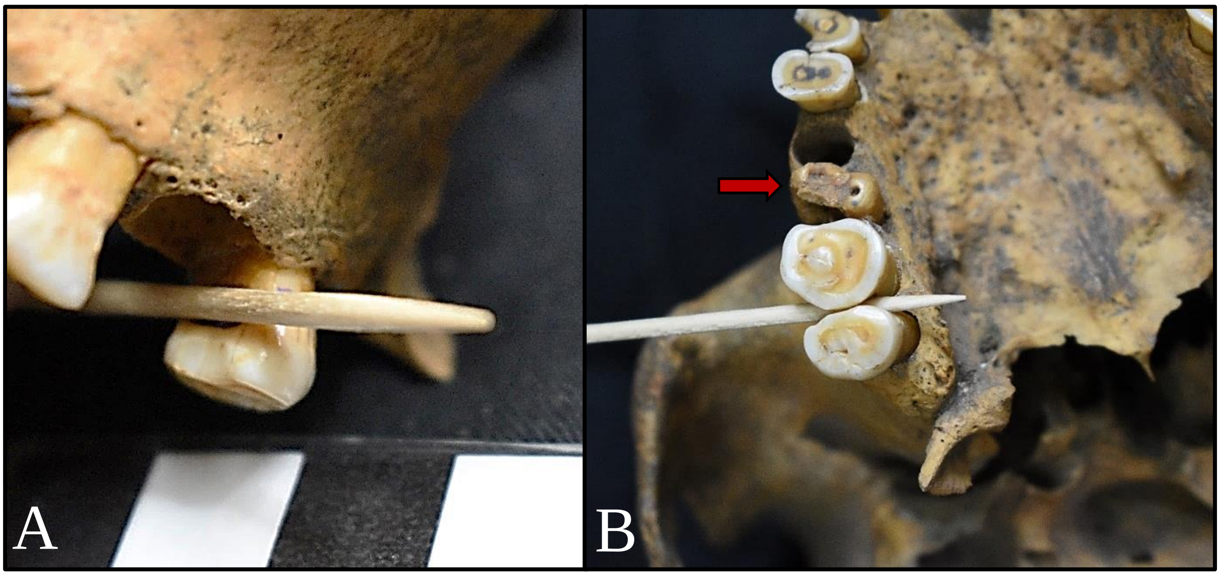


Figure 5.14: Examples of how a dental item, such as a 'toothpick' (length 63mm, thickness at widest point 2 mm), may fit between the teeth through the interproximal groove to clean between the teeth (UCT 218b). Figure A exhibits an interproximal groove on the mesial side of the left maxillary third molar (2.8), where the neighbouring tooth was lost post-mortem. Figure B exhibits the right maxillary second and third molars (1.7, 1.8, respectively). Note the non-vital tooth (red arrow, right maxillary first molar, 1.6) next to the right maxillary second molar (1.7).

5.9 Demographic variation in wear discussion

The data by sex, age-at-death, space, and time were remarkably similar for both quantity and direction, where partial dentine exposure and horizontal and plane wear were prevalent across assessments. Although this study included macroscopic observations, the results of long-term homogeneity in diet and behaviour may align with past studies discussing long-term population continuity (Stynder, Ackermann & Sealy, 2007; Black, 2014; Irish et al., 2014). Identifying slight variances can elucidate nuances, and certain facets of these results on quantity and direction were outlined earlier. These combined results are considered below against assessed demographic variables and possible tool-use wear examples.

Sexual dimorphism and wear

Researchers have suggested that female sAHGH typically show greater wear on the anterior teeth as a result of the overloading of the dentition caused by gender-based occupational tasks (Van Reenen, 1966, 1992; Morris, 1992a; Botha & Steyn, 2015). Such tasks may have included preparing hides, plant stripping, and 'snacking' on gathered foods during foraging expeditions (Van Reenen, 1964; Sealy et al., 1992). These data did not find appreciable effects between sexes in anterior wear for quantity or direction, and mean wear quantity indices indicated that female anterior wear was 2.9 and males were 3, closely ranging between partial dentine and complete dentine exposure. These results imply that sAHGH sexual dimorphism was not as distinct in this study as previously reported. Van Reenen (1992) also reported conflicting results, as wear was higher for males in archaeological sAHGH yet higher for females of living Kalahari San. The slight increase in male average wear may be related to sampling bias, as males had more scored surfaces for quantity (55%; 4595/8355) to females (45%; 3760/8355) and more teeth present overall (54%; 2821/5103) than females (46%; 2282/5103). Alternatively, a different dietary arrangement in terms of the amount of food consumed slightly expediting rates of wear may also explain modest differences by sex, as demonstrated ethnographically in the Kalahari by Lee (1979) through quantification of calorie intake. However, craniofacial morphology and occlusal loading variability vary between sexes, so rates of wear may have been reduced for females due to facial morphology regardless of consuming similar foods (Mays, 2015).

Overall, scored surfaces for direction were similar between sexes, where males had 55% (4670/10375) to females with 45% (3812/10375), and all sexes exhibited horizontal and plane wear as the leading stage. Statistically, female maxillae were over one times more likely for maxillary oblique and plane wear and almost three times more likely for maxillary oblique and concave wear. Increased oblique wear odds were potentially due to using the teeth for specific tasks, such as plant, sinew, and hide stripping (Van Reenen, 1992), as opposed to largely being from dietary differences considering similar quantity results and because sAHGH communities generally practised group 'sharing', equally distributing resources (Lee, 1979; Sealy & van der Merwe, 1988; Boonzaier et al., 1996). Female occupational roles may have incorporated plant and hide stripping using the teeth more frequently, as demonstrated by higher odds of oblique wear and as gleaned from ethnographic reports of gender-based labour in the Kalahari, where female ethnographic San and/or Khoe tended to be responsible for food, hut, and tool preparation (Lee, 1979). Gibbon and Grimoud (2014) reported similar results using the Brabant index on Iron Age Zambian remains, where females exhibited different wear directions in incisors suggestive of tool use, despite evidence of a similar diet. Although their study included two samples from similar periods and geographic regions, the results from this thesis imply deviating examples from the expectation of horizontal and plane wear suggest high abrasive contamination and the possible female dominant use of teeth as tools throughout the Holocene.

Increased odds for oblique and concave wear directions may also be multifactorial. They may have been due to an interplay of tool use and environmental abrasion, as demonstrated through additional, isolated examples of notches and grooves mostly occurring in the female dentition. Where quantity results did not exhibit appreciable results between sexes, females reportedly led foraging expeditions, and 'snacking' on these expeditions may have introduced additional exogenous contaminants into the female masticatory system (Sealy et al., 1992). Therefore, where both sexes likely shared similar diets and were both required to utilise the teeth as tools, it is again suggested that variation in wear direction may be related to the implementation of various gender-based occupational tasks or behaviours between groups.

It is worth noting that sAHGH sexual dimorphism has varied between sites and periods across southern Africa and global HGH studies, and absent sexual dimorphism in tooth wear is not novel. For example, Morris (1992a) reported site-specific differences in wear for sexes for two southern African groups practising HGH lifeways (samples from Riet River and Kakamas). The two groups did not exhibit sexual dimorphism in wear quantity, yet the third contact period group (Griqua) was significantly dimorphic. The author also indicated that the anterior teeth wore consistently ahead of the posterior teeth across all sexes, as was apparent in these quantity results. Despite global HGH populations also demonstrating sexual dimorphism in wear (Clement & Hillson, 2012; Littleton et al., 2013; Littleton, 2017), research has also shown examples of variation in broad assessments, such as Górka and colleagues (2015) reporting on sexual dimorphism in first molar wear in four HGH groups from various continents: Agta of the Philippines, Australian Aborigines, Kalahari San and North American Inuit. The authors found no significant sexual dimorphism in wear between the global groups and suggested that any distinct sex-specific roles did not appreciably affect dental wear.

In this sample and despite similar diets, there may have been variation in behaviours between sexes in sAHGH as demonstrated through direction and non-masticatory wear. However, this was not significantly reflected in overall wear quantity, and rather through examples including smaller sample sizes from wear direction and non-masticatory wear results. This suggested the possible presence of gender-based labour roles, relative to past research, although with variation between sites on how these roles were divided. Using stable isotopes, Sealy and van der Merwe (1988) reported that at coastal sites, male and female diets became isotopically similar upon the advent of pastoralism from 2000 BP; therefore, site-specific sexual dimorphism is possible throughout the Holocene at particular periods. Although, when studying sAHGH dentition holistically and macroscopically, as in this study, any greater differences attributable to diet are insignificant. It can be generally suggested that both sexes shared diets with similar processing strategies and were both required to utilise the teeth as tools, although with potential variation between groups, sites, or periods. Gender-based roles may be better identified through more extensive future research on non-masticatory markers of the teeth.

Age-estimation and wear

Age has long been a positively correlated principle mechanism of dental wear (Richards & Brown, 1981), complicating behavioural inferences between age and wear. As expected, increasing wear quantity for age was significant for all quantity models, where young and young/middle adults demonstrated reduced odds for advancing wear quantity, and old adults had greater odds for increasing wear quantity. Mean wear indices also elucidated gradual increases in wear quantity averages with each subsequent age category. Morris (1992a) suggested advanced wear occurred early in young adult sAHGH, and this thesis also displayed young adult partial dentine exposure as the most frequent stage for anterior teeth and the buccal side of first premolars and first molars. Moreover, the incisors demonstrated an incidence rate of zero for wear scores below dentine exposure. Absence of wear and enamel polishing were the most frequent quantity stages for the lingual side of the first premolars and all surfaces of the second premolars, second and third molars. These sequences align with times of eruption (Esan & Schepartz, 2018) and complex premolar morphology (Górka, 2016), where the latter tends to affect regular wear rates (Sperber, 2017). Similarly, wear direction was frequently absent for young adults in the posterior teeth considering several young adult teeth were slightly worn, and this followed the time of eruption.

The early appearance of dentine exposure in young adults suggested that the teeth began rapidly wearing soon after eruption in childhood which affirms similar tough and fibrous diets to the older individuals. This pattern was also notable in the anterior teeth, which suggests overuse of the anterior teeth from an early age. Littleton (2017) reported similar wear results in Aboriginal Australians and associated the findings with labour, despite positive correlations between wear and age. These data on anterior wear may suggest an expectation existed for young adults to contribute to community tasks from an early age. These observations, being task-based instead of dietary, are further supported by young adult first molars exhibiting enamel polishing, where the incisors exhibited no occurrences of enamel polishing or absence of wear. Considering first molars typically wear the fastest due to earlier eruption times (Hillson, 2008), enamel polishing in young adulthood implies the first molars wore down at a standard rate relative to diet, and the low to no incidence rate of enamel polishing in anterior teeth may suggest anterior tooth use for non-masticatory tasks.

These results do not represent discrete groupings and suggest some sampling bias, as middle and surrounding transition categories display enamel polishing on anterior teeth, although infrequently. Old adults exhibited very few occurrences of enamel polishing, and over 50% of anterior teeth exhibited pulp chamber exposure, further supporting the idea that sAHGH maintained the use of anterior teeth for tasks throughout life. Regarding young/middle, middle and middle/old adults, there was less variability between these age groups, except that as the frequency of partial dentine exposure decreased with each subsequent age group, complete dentine exposure increased, which met wear rate expectations of increasing wear quantity with age.

Horizontal and plane direction was prevalent across all age categories supporting a plant-based diet introduced at an early age, despite surfaces scored clustering around young/middle (42%; 2367/5693), middle (21%; 1190/5693), and middle/old (28%; 1577/10375) adult categories. An oblique and plane direction was more apparent when assessing frequencies for the older age groupings, principally middle-aged, middle/old-aged and old-aged adults. These observations appear to be multifactorial because of the abovementioned distributions and small sample sizes across age categories. Additionally, it may have been task-based wear that encouraged oblique directions (Milner & Larsen, 1991), such as plant or hide stripping as one aged, or occlusal directions adjusted as quantity increased (Hall, 1976; Osborn, 1982). Nevertheless, direction was frequently absent for posterior teeth in young adults apart from anterior teeth, supporting quantity results that anterior teeth were more frequently utilised from an early age.

Pfeiffer and colleagues (2020) reported an expectation for first and second molar flattening of cusps by middle adulthood, yet ‘flattening of cusps’ occurred rather frequently across all tooth types since young adulthood in this thesis. In early quantity stages, such as during enamel polishing, there are regions considered 'tip crush areas', where flat facets develop on the tips of the maxillary molar cusps from puncture-crushing during the masticatory cycle, as the cusp tips occlude with depressions in the mandibular molars (Fiorenza, Benazzi & Kullmer, 2011). These facets do not necessarily correlate with particular diets or behaviours; they occur as the teeth begin to wear. Such masticatory mechanisms must be considered when observing dental wear direction and are also potentially responsible for early stages of wear direction; as previously mentioned, the direction cannot be accurately inferred until the appearance of distinct degrees of wear quantity, and this likely affected some observations in this thesis.

Spatial regions and wear

Sampling distribution must be noted for spatial variables as coastal teeth had 86% (8716/10101) scorable surfaces compared to only 14% (1385/10101) for inland surfaces. The abundance of food along the southern African coast was due to the productivity of the Indian and Atlantic oceans supplying marine protein (Pfeiffer & Sealy, 2006), and coastal communities that consumed more marine resources may have had heavier wear from a steady supply of food and increased abrasion from sandy contamination (Walker, 1978; Sealy & van der Merwe, 1988; Sealy et al., 1992; Pfeiffer et al., 2020). Although spatial variables did not exhibit appreciable effects, this study met these expectations through mean wear quantity indices, where coastal teeth exhibited a mean wear quantity of 2.3 *versus* 2.1 for inland, and relative frequencies for pulp chamber exposure occurred more often along the coast. An exception was relative frequencies of pulp chamber exposure in inland first molars that was greater than coastal first molars. As well, inland individuals exhibited increased relative frequencies for complete dentine exposure than coastal individuals, in addition to oblique and plane wear in the anterior teeth and horizontal and concave in the posterior dentition. Direction regression models supported these results by predicting reduced odds for oblique wear (concave and plane) for coastal individuals, suggesting that inland individuals exhibited oblique wear directions more frequently. This may have been because the interior had more abrasive environmental contamination through roasting, curing, and drying of terrestrial meats, as reported in inland sites such as Boomplaas cave (Deacon, 1995; Russell & Lander, 2015) or simply due to sampling distribution relying on coastal remains, thus, overestimating inland individuals. Otherwise, and as expected, both regions predominantly demonstrated horizontal and plane direction as coastal and inland diets were of mixed economies with a reliance on plant foods (Deacon, 1984; Sealy, 1984: 198; Churchill & Morris, 1998; El-Zaatari, 2010).

Over the decades, several authors reported on Inuit populations consuming high amounts of raw, frozen, and dried meat (Mayhall, 1970: 197; Costa, 1980; Keenleyside, 1998; Scott & Winn, 2011; Fiorenza et al., 2018). The common consensus between these studies was that consuming unprocessed or naturally processed meats (i.e., frozen or dried) ultimately required longer chewing times. Although food processing techniques and dietary habits were similar between both southern African spatial regions, steeper angles on the occlusal plane may also form from an extended period in the shearing phase of the chewing cycle which is more likely when masticating mammalian protein or dried meat (Kay & Hiiemae, 1974; Fiorenza et al., 2018), as relevant for inland sites (Deacon, 1995; Russell & Lander, 2015). Marine protein in the form of fish or shellfish along the coast shaped the core protein component of a coastal diet, wherein the softer consistencies may have reduced mastication efforts and thus reduced odds for coastal oblique wear. These data suggested that the masticatory cycle may have marginally varied between regions depending on what an individual relied on to consume, how it was processed, and the number of abrasive particles present.

The presence of more abrasive particles, either through the environment (Wessels et al., 2011), food processing, or tool use (e.g., grindstones) (Lombard et al., 2012), may demonstrate more uneven wear between buccal and lingual sides (Kaidonis, 2008); however, there were few differences between posterior cusps for wear direction. Apart from marginal differences in relative frequencies for quantity, overall rates of wear between molar cusps were remarkably similar, suggesting both coastal and inland individuals experienced similar degrees of abrasion from contamination of exogenous particles affecting the entire occlusal surface. Both regions are sandy by nature, and both diets involved fibrous plant foods, and the expectation for horizontal and flat wear predominating the dentition was met.

Temporal variation and wear

There were few differences and no appreciable effects between pre/post-2000 BP wear quantities, and similar results were obtained for each tooth type across temporal divisions. There were 59% (5027/8528) of scorable surfaces for quantity in pre-2000 BP and 41% (3501/8528) post-2000 BP, with slight variation in mean wear for pre-2000 BP (2.29) and post-2000 BP (2.24), likely from pre-2000 BP having slightly more scorable surfaces. Holocene divisions also reflected this pattern, and a mean of 2.3 reflected the earlier and middle Holocene and 2.2 for the later Holocene. These data aligned with observations by Pfeiffer (2007), who reported a lack of variability in sAHGH health and stress between temporal periods, suggesting behaviours were consistent across time.

For wear direction, individuals from pre-2000 BP were over one times more likely for oblique and plane wear than post-2000 BP, further supported by appreciable results in initial models for both the earlier and middle Holocene. These data implied oblique wear decreased in post-2000 BP, a period that Sealy and van der Merwe (1988) associated with an increasing terrestrial diet at some sites despite uninterrupted coastal habitation. This should have reflected increasing plane wear with increasing terrestrial dietary components. Therefore, pre-2000 BP oblique wear may be due to greater variation in the diet or non-masticatory use of the teeth. Although regressions did not predict appreciable effects regarding concave wear, tabulated results for temporal variation in wear direction demonstrated higher incidence rates for post-2000 BP concave wear. Concave wear may support earlier inferences of increasing use of grindstones post-2000 BP that may have contributed to exogenous abrasion (Copley et al., 2004; Sadr, 2008a). The regression's unmeaningful results and the marked frequencies of plane wear with some insignificant interindividual variation may otherwise suggest dietary homogeneity between sAHGH of a mixed diet relying on plant-based products reflected throughout the Holocene.

SAHGH diets and cultural habits varied throughout the Holocene, inconsistently alternating between terrestrial and marine resources, and otherwise alternating between gathering and herding subsistence strategies post-2000 BP (Sealy et al., 1992; Pfeiffer, 2007). If a pre-2000 BP diet depended on marine resources (Sealy & van der Merwe, 1988)—and considering this study relied on coastal individuals—the expectation would be to observe higher degrees of wear in pre-2000 BP. However, as exhibited in spatial means for wear quantity, rates of wear were similar across southern Africa. Pfeiffer and Sealy (2006) also suggested an expectation of reduced wear rates in the middle Holocene due to resource scarcity from rapid population growth, which would translate to lower quantity stages in the middle Holocene. Although dental wear is a direct reflection of a person's interaction with the environment, authors such as Irish and colleagues (2014) concluded that there was an overall temporal and spatial population homogeneity for sAHGH populations as evidenced by dental traits. Therefore, any unspecified and isolated environmental or cultural changes that may have introduced some divergence from expectations did not significantly affect the overall sAHGH population. These data and the unremarkable comparisons thus support the idea that there were no measurable changes in food consistency, as a study by Watson (2008) found systematic variation in both wear quantity and direction between multiple archaeological phases during the North American Early Agricultural period, which suggested changes in food consistency or dietary choices over time. Therefore, these results suggest a relative homogeneity in dietary choices and a substantial presence of abrasive elements in most southern African biomes across the Holocene for sAHGH.

Chapter summary

This chapter included dental wear reliability results and an optimised Brabant index method developed by the author, including a visual guide and multicuspid scoring. It further justified the necessity behind standardised method optimisation in dental wear studies to better suit different populations and lifeways by demonstrating notable improvements following the implementation of the improved method based on HGH teeth wear patterns.

Prior bioarchaeological research on sAHGH populations has demonstrated heavy, flat macrowear, often greater in the anterior teeth, and seldom provided discussed non-masticatory use of the teeth. In this chapter, I demonstrated that a systematic assessment of sAHGH dentition corresponded with local and global expectations of a diet of tough and fibrous foods. Heavy wear in younger adults suggested the use of the teeth and a tougher diet from youth, and holistically, appreciable sex differences in patterns of wear were not as prevalent. Where variation was observed, direction occasionally presented oblique and concave wear, likely from abrasive environmental contamination and using the teeth as tools. Photographic examples of non-masticatory use of the teeth were provided, though multifactorial, the possible origins of use-wear were discussed, including one possible case of oral hygiene behaviour. The subsequent chapter presents oral pathology results and individually discusses each assessed condition, whereas the interplay of wear with oral pathologies further compared to local and global literature is discussed in Chapter 7.

CHAPTER 6: ORAL PATHOLOGY & NOTABLE FEATURES RESULTS & DISCUSSION

This chapter commences with intra- and inter-reliability assessments and is proceeded with results and discussions for recorded oral pathologies (caries, AMTL, infectious lesions, EH, and dental trauma). Unless otherwise stated, the pathological condition was recorded once per tooth and, where pertinent, frequency of lesions per tooth.

6.1 Method repeatability

Inter and intra-reliability assessments for caries, AMTL, and EH are presented in Table 6.1. Intra-observer results were of almost or perfect agreement, and inter-observer results were of strong agreement. Due to errors in the initial data collection methodology for infectious lesions and trauma that necessitated late revisions, reliability assessments were not conducted on infectious lesions and trauma, which is acknowledged as a limitation of this thesis.

Table 6.1: Intra and inter-observer results using Cohen's Kappa for caries, antemortem tooth loss, and enamel hypoplasia.

Test	Variables	Kappa	95%CI†
Intra-observer (Author)	Caries	0.94	0.83 - 1.00
	AMTL	1.00	1.00
	EH	0.92	0.78 - 1.00
Inter-observer (Observer 2)	Caries	0.83	0.65 - 1.00
	AMTL	0.92	0.77 - 1.00
	EH	0.82	0.58 - 1.00

†95%CI is the confidence interval at 95%, demonstrating the lower and upper CI range.
AMTL = antemortem tooth loss
EH = enamel hypoplasia

6.2 Oral pathology inventory

The frequency of affected teeth for AMTL, caries, EH, infectious lesions, and trauma are presented in Figure 6.1, and the distribution between demographics for all pathological variables was insignificant. Infectious lesions were recorded on the alveolar bone but were illustrated to represent the likely affected tooth type relative to the lesion's location. Overall, 56% (105/369) of individuals had ≥1 pathological lesion, and 44% (164/369) of individuals had no observable dental pathology. Each tooth type in the dentition was also affected by ≥1 oral pathology, although the molars were most frequently affected by pathology on each side of both maxillae and mandibles. Each pathological condition varied in frequency across the dentition, and the subsequent sections include these individual observations.

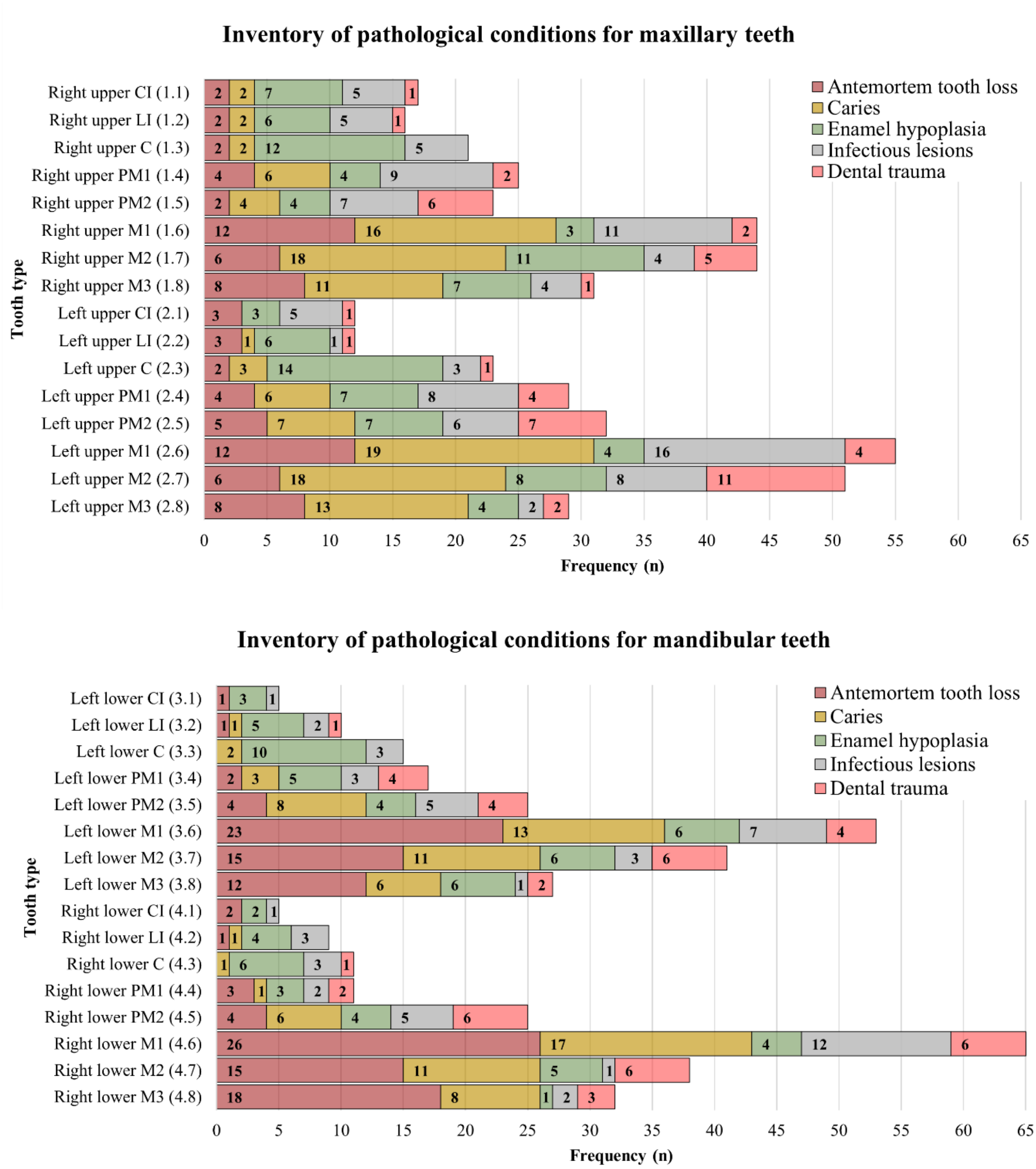


Figure 6.1: Frequency of antemortem tooth loss, caries, enamel hypoplasia, infectious lesions, and trauma on the teeth within the dental arcade.

6.3 Antemortem tooth loss

AMTL was diagnosed in 19% (70/369) of all analysed individuals, and 208 teeth were lost antemortem, with the frequency of AMTL per tooth illustrated in Figures 6.1 and 6.2.

Mandibles exhibited higher rates, representing 61% (127/208) of total observed AMTL, and maxillae showed 39% (81/208). The posterior teeth were most frequently affected, 35% (73/208) for first molars, followed by an almost equal representation between second and third molars. Subsequently, the first and second premolars had near equal representation. The anterior teeth were affected by AMTL less frequently, and there were no meaningful differences between the incisors or canines for AMTL occurrence.

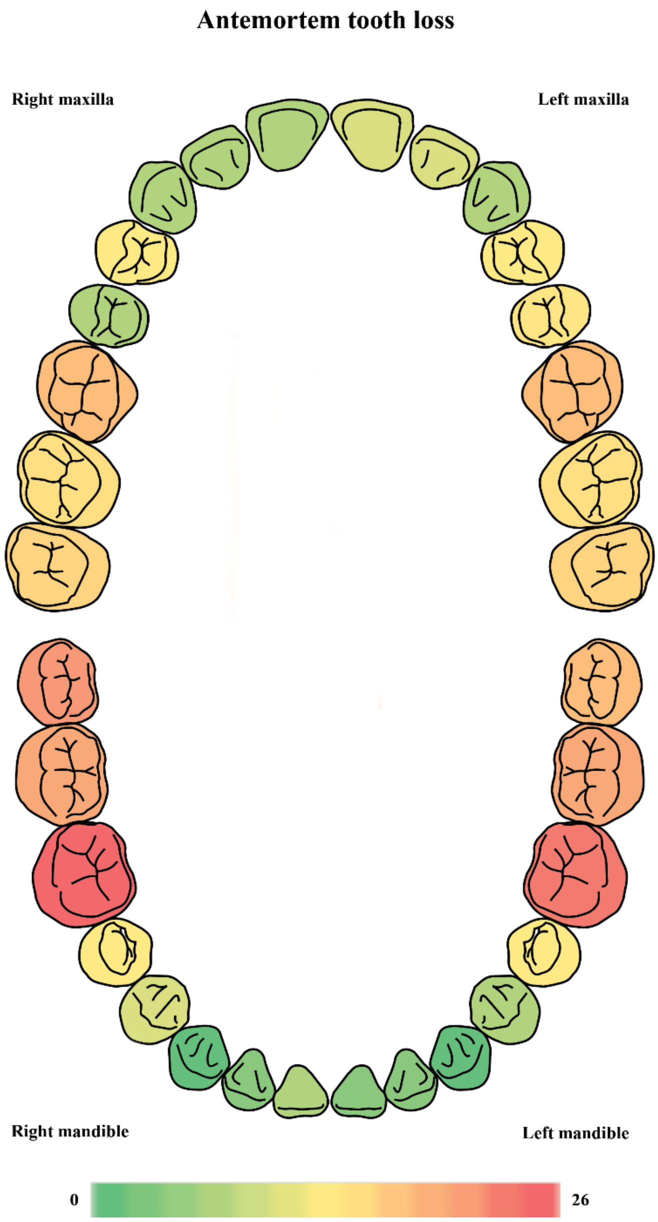


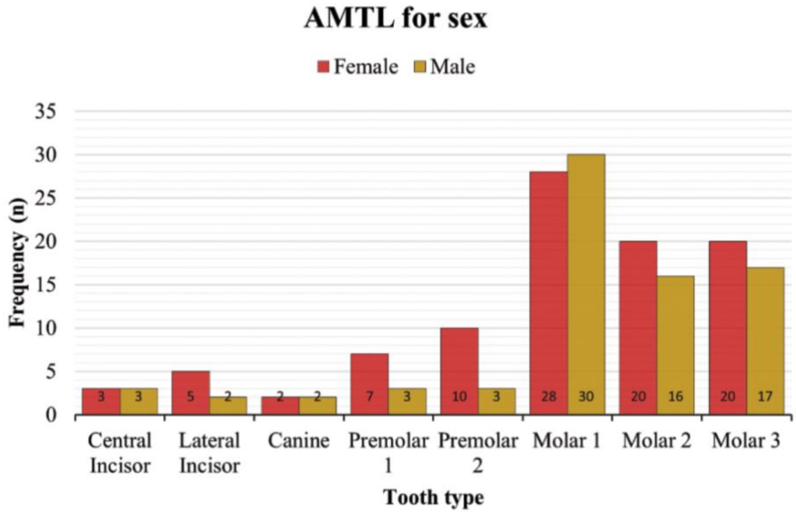
Figure 6.2: Heat map demonstrating the frequency of teeth with antemortem tooth loss on individual morphological tooth types for the entire dental arcade. Green shades indicate little to no presence, whereas red shades indicate higher prevalence.

AMTL prevalence between males and females was remarkably similar against total sexed individuals, showing 51% (26/51) for male individuals and 49% (25/51) for female individuals (Figure 6.3). For both sexes, AMTL occurrence per tooth type followed similar patterns where the molars were affected most frequently. However, female second premolars were affected slightly more, with 18% (10/95) of total teeth affected by AMTL, than any male premolar.

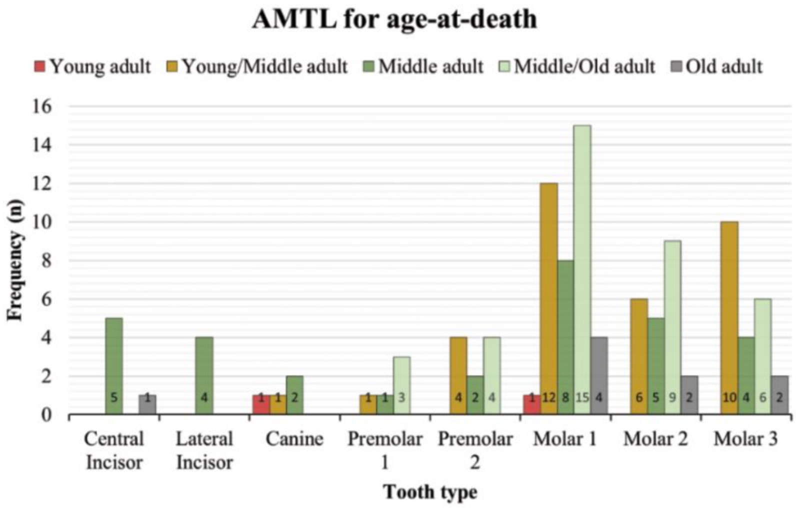
AMTL for individuals with age-estimates occurred most frequently in young/middle adults (39%; 14/37), closely followed by middle/old adults (27%; 10/37) (Figure 6.3). The remaining age categories were affected relatively infrequently, with the fewest number of AMTL occurring in young adults (5%; 2/37). Regarding age categories with substantial occurrences of teeth associated with AMTL, a higher frequency was observed on the molars, followed by premolars, and anterior teeth, however, middle-aged adults were exempt from this sequence. Rather, middle-aged adults demonstrated slightly higher occurrences of AMTL in the incisor teeth (29%; 9/31) compared to the premolar teeth (10%; 3/31).

In individuals with provenance, AMTL for spatial regions was common in coastal regions with 91% (62/68) of individuals *versus* inland individuals with 9% (6/68) (Figure 6.3). Despite the considerable difference between AMTL occurrence between coastal and inland due to sampling bias, the patterns of association for tooth types were similar between regions.

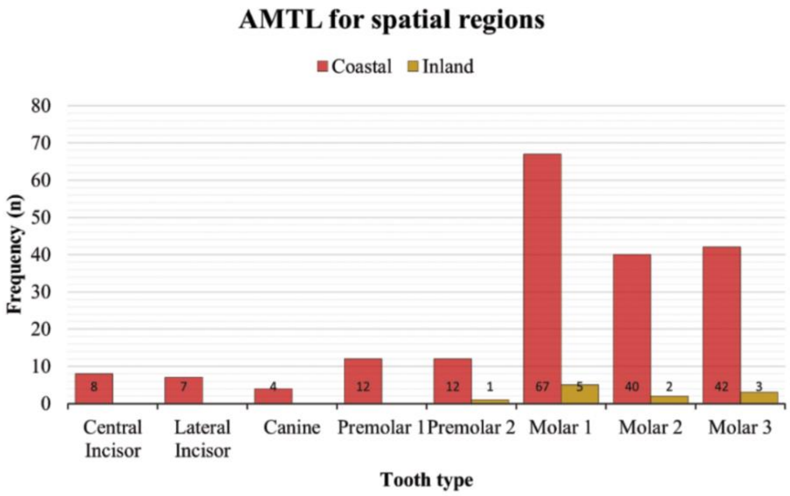
In dated individuals, AMTL occurrence in pre-2000 BP individuals was 60% (32/53) and in post-2000 BP was 40% (21/53) (Figure 6.4). Between pre/post-2000 BP periods, the patterns of association for AMTL on all tooth types were similar to previous variables. AMTL occurrence for Holocene divisions was almost equal in frequency for individuals from the middle Holocene (38%; 20/53) and the later Holocene (40%; 21/53), and least frequent in the earlier Holocene (23%; 12/53) (Figure 6.4).



	Frequency of AMTL	
	# of Individuals	**# of Teeth**
Variables	***n (%)***	***n (%)***
Sex		
Female	25 (49)	95 (56)
Male	26 (51)	76 (44)
Total sexed	**51 (73)**	**171 (82)**
Indeterminate	19 (27)	37 (18)
Total	**70**	**208**

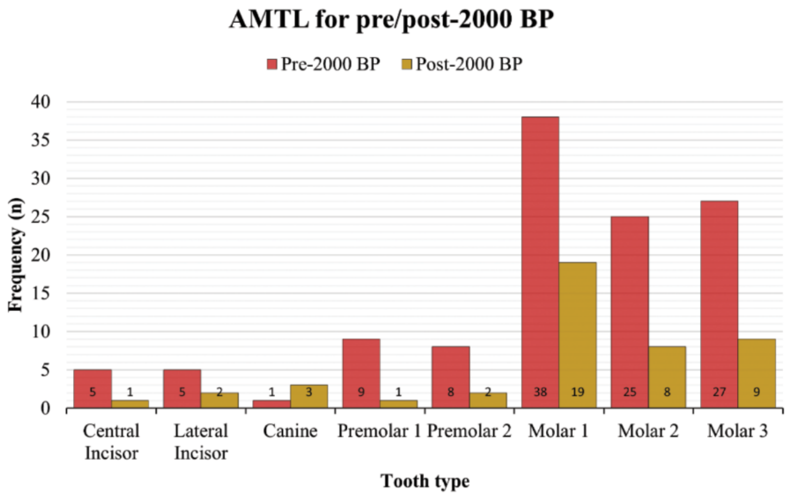


	Frequency of AMTL	
	# of Individuals	**# of Teeth**
Variables	***n (%)***	***n (%)***
Age-at-death estimate		
Young adult	2 (5)	2 (2)
Young/middle adult	14 (38)	34 (30)
Middle adult	7 (19)	31 (27)
Middle/old adult	10 (27)	37 (33)
Old adult	4 (11)	9 (8)
Total aged	**37 (53)**	**113 (54)**
Indeterminate	33 (47)	95 (46)
Total	**70**	**208**

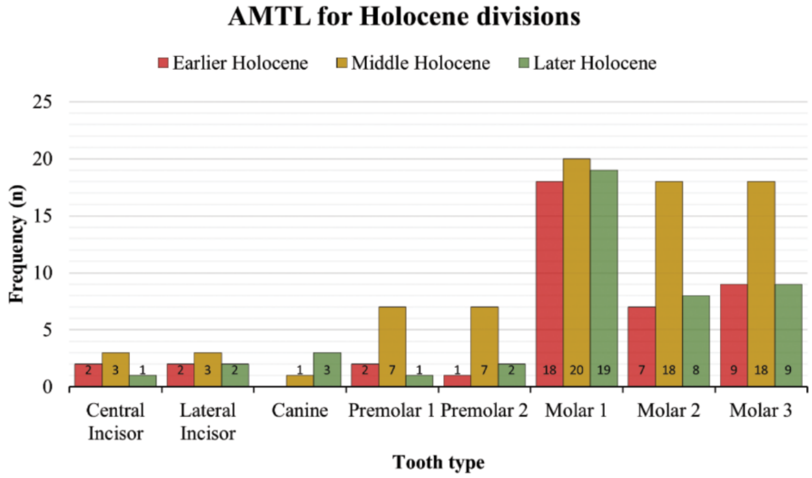


	Frequency of AMTL	
	# of Individuals	**# of Teeth**
Variables	***n (%)***	***n (%)***
Spatial regions		
Coastal	62 (91)	192 (95)
Inland	6 (9)	11 (5)
Total with provenance	**68 (97)**	**203 (98)**
Unknown	2 (3)	5 (2)
Total	**70**	**208**

Figure 6.3: Frequency of antemortem tooth loss on tooth types for demographic variables. From top to bottom: sex, age-at-death, and spatial regions. Totals and relative frequencies calculated against totals of scored variables and indeterminate/unknown frequencies calculated against the entire affected sample.



	Frequency of AMTL	
	# of Individuals	# of Teeth
Variables	***n (%)***	***n (%)***
Pre-/Post-2000 BP		
Pre-2000 BP	32 (60)	118 (72)
Post-2000 BP	21 (40)	45 (28)
Total dated	**53 (76)**	**163 (78)**
Unknown	17 (24)	45 (22)
Total	**70**	**208**



	Frequency of AMTL	
	# of Individuals	# of Teeth
Variables	***n (%)***	***n (%)***
Holocene divisions		
Earlier Holocene	12 (23)	41 (25)
Middle Holocene	20 (38)	77 (47)
Later Holocene	21 (40)	45 (28)
Total dated	**53 (76)**	**163 (78)**
Unknown	17 (24)	45 (22)
Total	**70**	**208**

Figure 6.4: Frequency of antemortem tooth loss on tooth types for demographic variables. From top to bottom: pre/post-2000 BP and Holocene divisions. Totals and relative frequencies calculated against totals of scored variables, and unknown frequencies calculated against the entire affected sample.

6.3.1 Multiple factors and their effect on antemortem tooth loss expression

AMTL incidence for tooth type and arcade, with the individual term being the random effect, was assessed using a logistic generalised linear mixed-effects regression model. AMTL in maxillae had more reduced odds than mandibles (OR=0.47, $p \leq 0.001$; Figure 6.5; Table 6.2). For tooth types (Figure 6.6, Table 6.2), in comparison with central incisors, canines demonstrated significantly reduced odds for AMTL (OR=0.23, p=0.16), whereas the lateral incisors and both premolars were not appreciably different. All three molars had greater odds for AMTL than central incisors (OR=13.6 for molar 1, $p \leq 0.001$; OR=5.09 for molar 2, $p \leq 0.001$; OR=7.18 for molar 3, $p \leq 0.001$). Based on these findings, the arcade was retained for further analyses, and tooth types were collapsed into morphological categories of anterior, premolars, and molars to reduce the number of factors. The initial interaction terms between tooth type and arcade were retained and run against all factors. Collapsing the individual teeth reduced the AIC from 1297.1 to 621.2, indicating a better fit for the model.

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	AMTL present (0)	AMTL absent (1)
Mandible	0.971031	0.028968
Maxilla	0.982554	0.017445

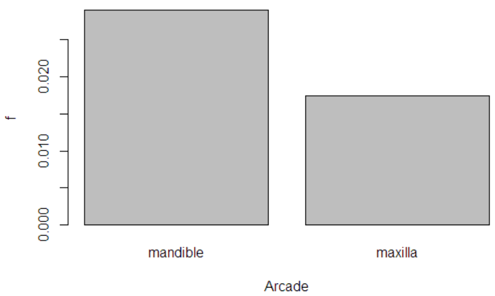

Figure 6.5: Antemortem tooth loss probability frequencies for dental arcade.

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	AMTL present (0)	AMTL absent (1)
Central incisor	0.9928251	0.007174
Lateral incisor	0.9938488	0.006151
Canine	0.9965841	0.003415
Premolar 1	0.9888412	0.011158
Premolar 2	0.9868881	0.013111
Molar 1	0.936077	0.063922
Molar 2	0.9630606	0.036939
Molar 3	0.9546798	0.04532

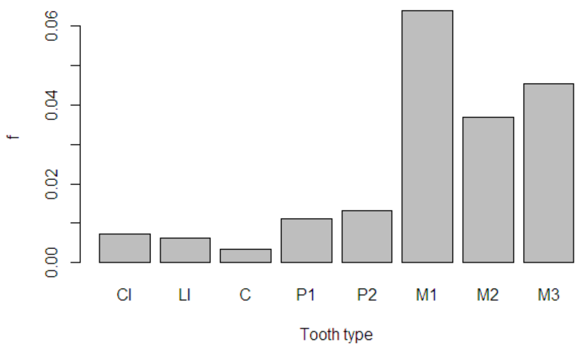


Figure 6.6: Antemortem tooth loss probability frequencies for tooth type.

Table 6.2: Results of logistic regression on effects of tooth type and arcade for tooth loss. OR=Odds ratio; The individual (random effect) had a variance of 5.569. Significance levels: * ≤ 0.05, ** ≤ 0.01, *** ≤0.001.

Factors	Estimate	OR	Std. Error	z value	*p* value	
Intercept	-9.40179	0.00008	0.67765	-13.874	$< 2 \times 10^{-6}$	***
Lateral incisor	-0.80811	0.45	0.51501	-1.569	0.116623	
Canine	-1.48078	0.23	0.61632	-2.403	0.016279	*
Premolar 1	-0.30705	0.74	0.46265	-0.664	0.506895	
Premolar 2	0.04849	1.05	0.43669	0.111	0.911580	
Molar 1	2.61294	13.6	0.36208	7.216	5.34×10^{-13}	***
Molar 2	1.62745	5.09	0.37231	4.371	1.24×10^{-5}	***
Molar 3	1.97240	7.19	0.37416	5.272	1.35×10^{-7}	***
Maxilla	-0.73419	0.48	0.20235	-3.628	0.000285	***

A model regression was again performed with the individual as the random effect to assess the effects of several factors on AMTL presence or absence. The fixed factors included full interaction between collapsed morphological tooth groups and arcade, as well as estimated age-at-death, estimated sex, temporal allocation in pre/post-2000 BP, and whether the individual was inland or coastal. The results, as demonstrated in Table 6.3, maintained the aforementioned patterns of association (Table 6.2) where molars demonstrated greater odds (OR=8.56, $p \leq 0.001$) and anterior teeth, overall, demonstrated reduced odds for AMTL (OR=0.07, p=0.01). More specifically, the maxillary anterior teeth had greater odds of AMTL (OR=13.3, p=0.02) than the mandibular anterior teeth. Additionally, the male sex had reduced odds of AMTL (OR=0.26, p=0.09, Figure 6.7) compared to the female sex.

	AMTL present (0)	AMTL absent (1)
Female	0.972205	0.027794
Male	0.980778	0.019221

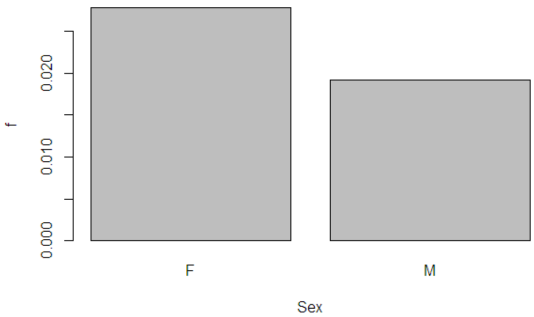


Figure 6.7: Antemortem tooth loss probability frequencies for sex.

Table 6.3: Results of logistic regression on effects of multiple factors for tooth loss. OR=Odds ratio. The individual (random effect) had a variance of 5.255. Significance levels: **.** ≤ 0.1, * ≤ 0.05, ** ≤ 0.01, *** ≤0.001; † the lack of any appreciable temporal effect was reiterated when split into earlier, middle and later Holocene.

Factor	**Estimate**	**OR**	**Std. Error**	**z value**	***p* value**	
Intercept	-7.3427	0.0006	1.7259	-4.254	1.86×10^{-5}	***
Anterior	-2.5630	0.08	1.0061	-2.547	0.0109	*
Molar	2.1473	8.56	0.4563	4.706	2.53×10^{-6}	***
Maxilla	-0.5541	0.57	0.5835	-0.950	0.3423	
Young/middle adult	-0.1662	0.85	1.6776	-0.099	0.9211	
Middle adult	-0.3166	0.73	1.7537	-0.181	0.8568	
Middle/old adult	-0.2204	0.80	1.7864	-0.123	0.9018	
Old adult	2.2891	9.87	2.3000	0.995	0.3196	
Pre2000†	-0.2906	0.75	0.8495	-0.342	0.7323	
Male	-1.3347	0.26	0.8112	-1.645	0.0999	.
Inland	-1.0825	0.34	1.2004	-0.902	0.3672	
Maxillary anterior	2.5851	13.3	1.1404	2.267	0.0234	*
Maxillary molar	-0.7374	0.48	0.6580	-1.12	0.2624	

6.3.2 Antemortem tooth loss discussion

AMTL diagnosed in 19% (70/369) of analysed individuals represented a moderate incidence rate reflective of a HGH lifestyle (Marklein et al., 2019). Gibbon and Davies (2020) reported AMTL to occur in 36% (52/150) of Holocene sAHGH individuals, and Morris (1992a) also reported on the varying rates of tooth loss between several sAHGH publications (Drennan, 1929; Van Reenen, 1964, 1966). Overall, Morris (1992a) reported frequency of individuals with AMTL varied with the inclusion of older adults and across periods, as tooth loss increased with age and with the inclusion of contact period San and/or Khoe individuals who inhabited farms and ate contemporary diets (i.e., refined carbohydrates). Higher incidence rates of AMTL are typically associated with populations whose subsistence base incorporates refined carbohydrates, such as in agriculturalists (Marklein et al., 2019), further demonstrated in sAHGH by Botha and Steyn (2015), who reported AMTL on 37.9% (44/116) in a contact period San and/or Khoe sample dating to the late 19th and early 20th centuries. In contact period individuals, increased AMTL was also due to medical intervention, where Morris (1992a) also reported that some contemporary San and/or Khoe would undergo dental extraction.

Globally, observations between HGH populations and contemporary archaeological populations, notably agriculturalists, follow predictable patterns. For example, Turner II (1979) reported AMTL on the Jōmon, a HGH population from Japan, to have occurred in 11.6% of the population. In comparison, Lukacs (1992) reported AMTL in the Harappan, an agriculturalist population from Pakistan, on 31.7% of individuals. However, variation must be noted, as a study on a mediaeval French population by Esclassan and colleagues (2009) reported low rates, of which 8.7% of individuals exhibited AMTL despite maintaining a diet high in starch and sugars. The authors compared their data to an Italian mediaeval site of a similar period, reporting higher rates of 18.2% of AMTL. The authors concluded that variations in tooth loss incidence results depend on sample distribution, as in longer lifespans will introduce higher rates of AMTL and caries. Variation in AMTL across sAHGH studies may also be due to varied sample distributions and sociodemographic contexts.

AMTL from heavy wearing favours premolar and molar teeth, but AMTL from fractures or interpersonal violence favour the anterior teeth, often the maxillary anterior teeth (Lukacs, 2007). Research has shown advanced wearing in the anterior teeth can be a likely aetiology for anterior AMTL in heavy-wear populations such as HGH (Costa, 1980; Larsen, 1995; Nelson, 2016). The results from this thesis demonstrated greater odds for tooth loss on the molars (OR=8.56, $p\leq0.001$), principally the first molar (OR=13.6, $p\leq0.001$), and the maxillary anterior teeth also demonstrated much greater odds (OR=13.3, $p=0.02$) for AMTL. These findings on tooth types largely correspond with Gibbon and Davies (2020), who reported AMTL affected the molars, followed by the incisors, although without specifying the jaw. Aetiologically, first molars were also the primary tooth type impacted by dental wear, caries, and infectious lesions, whereas anterior teeth were manifestly affected by dental wear. AMTL is typically associated with inflammation or infection through association with the development of another dental pathology that renders the tooth vulnerable (Marklein et al., 2019); therefore, there is likely an interplay between AMTL, dental decay, and wear in this study. It is worth noting that dental wear quantity also demonstrated greater odds for mandibular anterior teeth, which do not align with the AMTL results. In fact, when assessing the jaws together, the results on the anterior teeth exhibited an overall reduced probability of AMTL (OR=0.08, $p=0.01$), suggesting greater odds for tooth loss incidence was isolated to the maxillary anterior teeth.

In addition to dental decay and wear, AMTL occurs from trauma and ablation (Lukacs, 2007), yet these data on anterior teeth did not demonstrate a high frequency of dental trauma in the anterior teeth either. There was also no clear evidence of consistent and symmetrical patterns indicating intentional dental ablation or evulsion of the anterior teeth in this sample, as has been reported as possible in numerous southern African (Briedenhann & Van Reenen, 1985; Van Reenen & Briedenhann, 1986; Morris, 1998; Friedling & Morris, 2005) and global populations (Merbs, 1968; Blakely & Beck, 1984; Alt & Pichler, 1998; Reichart, Creutz & Scheifele, 2007; Pinchi et al., 2015). Therefore, anterior tooth luxation from root trauma, for example, may have resulted in the eventual loss of the tooth in this sample, wherein research on dental trauma has reported the front teeth being common locations for crown and root trauma (Çobankara & Üngör, 2007) with accidental incisor injury ranging from 4% to 49% in contemporary populations (Kania et al., 1996). Future research that assessed sAHGH roots for trauma using radiographic imaging would be of benefit to sAHGH research. The precise aetiology for AMTL is unclear and complicated, and estimating the exact proportion of its associated conditions in archaeological populations is virtually impossible (Lukacs, 2007), as demonstrated further in this discussion. Consequently, these AMTL results indicate multiple underlying causal factors that require further investigation using alternative techniques.

6.3.2.1 Antemortem tooth loss and demographics

Although insignificant by way of a 95% p value cut-off ($p \leq 0.05$) but still relevant (Smith, 2020), male individuals demonstrated slightly reduced odds (OR=0.26, p=0.09) for AMTL ahead of females. This result may support expectations for females displaying higher rates of AMTL as a reflection of gender-based occupational use of the dentition resulting in unique patterns of tooth loss (Merbs, 1968; Lukacs, 2007). In this sample, females also exhibited heavier anterior tooth wear than males, which is a likely contributor to tooth loss based on this study's results. The female second premolars were affected more frequently by AMTL than any male premolar tooth, which corresponds with infectious lesion prevalence being higher in female second premolars than in males, also a likely contributor to tooth loss from pulpal necrosis (Forshaw, 2014).

AMTL was associated with increasing age categories, but these results were neither significant nor consistent. The expectation was to observe a steadily increasing rate of AMTL with each subsequent age category (Lukacs, 2007), and although young adults exhibited the fewest cases of AMTL, old-aged adults overall had the second-fewest occurrences. In contrast, the remaining frequencies varied inconsistently between young/middle, middle, and middle/old adults. There should be a further correlation between age and the amount of anterior tooth loss. Tooth loss in older age may occur from root resorption, where the area of contact between the root and the alveolar bone diminishes, increasing the chance of tooth loss chiefly in single-rooted teeth (Scott, 2020). These data did not meet this expectation either, where anterior AMTL for old adults occurred once in the sample. One explanation may be the presence of hypercementosis that prevented tooth loss (Tang, Le Cabec & Antoine, 2016), as hypercementosis was diagnosed through abscesses cavities or on loose teeth for a few individuals (n = 4). However, considering the sample distribution was inconsistent between age groups as discussed in Chapter 4, these results likely reflect sample bias rather than inferential observations of age-related AMTL.

Spatially, there was a clear discrepancy in AMTL observed for coastal (91%; 62/68) over inland (9%; 6/68) regions in this sample, and sampling bias must be acknowledged. Still, coastal and inland individuals exhibited AMTL on molars more frequently than anterior and premolar teeth, although insignificant and of a small sample size, correlating with the possibility that dental decay was more frequent in the molars to instigate tooth loss (Temple, 2016). As previously discussed, dental decay is a likely aetiology for AMTL in the molars.

Interestingly, the number of teeth affected in the middle Holocene (47%, 77/163) far surpassed the later Holocene (28%, 45/163); albeit insignificantly, the later Holocene had more individuals with AMTL (40%, 21/53) than the middle Holocene (38%, 20/53). These results demonstrated that there were more individuals in the later Holocene with AMTL, yet more teeth were lost antemortem per individual within the middle Holocene. These contrasting results may be associated with carious lesion growth, considering a similar pattern was observed between Holocene divisions for caries (see Section 6.4.2.1), of which more teeth were affected within the middle Holocene but more individuals in the later Holocene. It is not unusual for one carious lesion to predispose the teeth around it to develop additional lesions if left untreated, triggering an inflammatory response on multiple teeth, often resulting in tooth loss (Hillson, 2001). Nonetheless, these contrasting frequencies between the number of teeth and individuals affected may be associated with a dietary shift from 2000 BP. Sealy and van der Merwe (1988) reported on the chronological patterning of marine food use in the Cape, highlighting a mixed marine and terrestrial diet in post-2000 BP, as opposed to a greater reliance on marine resources in pre-2000 BP. The authors suggested marine diet tooth wear to be more significant from abrasive contamination of sand, and with a decreased reliance on marine foods post-2000 BP, the wear quantity may have reduced. This would decrease the likelihood of advanced wear and its association with tooth loss, gleaned as an aetiological possibility from these data. It is worth noting that coastal remains dominated Sealy and van der

Merwe's (1988) study, and as demonstrated in the abovementioned spatial results for AMTL, variations between inland and coastal regions, along with possible AMTL aetiological factors, were likely related to caries above wear between regions. Although there were no appreciable differences between AMTL and demographic factors, population-wide reflections of dietary shifts may have been subtle, affecting some smaller groups more than others, and thus not significantly reflecting in the holistic results. Otherwise, this study's findings may support population continuity (Stynder, Ackermann & Sealy, 2007; Black, 2014; Irish et al., 2014), where sAHGH individuals adapted well to the southern African environment rather than remaining in a perpetual state of survival.

6.4 Caries

Carious teeth were observed for 28% (102/369) of total analysed individuals and 3.5% (217/6271) of total present teeth, and caries frequency is presented in Figures 6.1 and 6.8. There were 217 total carious teeth with a total of 233 carious lesions. The posterior teeth were most frequently affected, where first molars represented 30% (65/217) of total teeth with caries, closely followed by second molars with 27% (58/217) and third molars with 18% (38/217). The first and second premolars were almost equally affected by caries, and the anterior teeth were the least affected tooth types.

Most carious lesions were present at the CEJ, with 61% (143/233) of total lesions, followed by coronal lesions (38%; 89/233). Regarding orientation, most carious lesions were mesial (35%; 81/233) or distal (33%; 78/233), and of these, 15% (34/233) were interproximal (Table 6.4). Occlusal lesion location represented 21% (48/233) of total carious lesions, and gross lesions occurred 6% (14/233) of the time. Buccal and lingual lesions were uncommon.

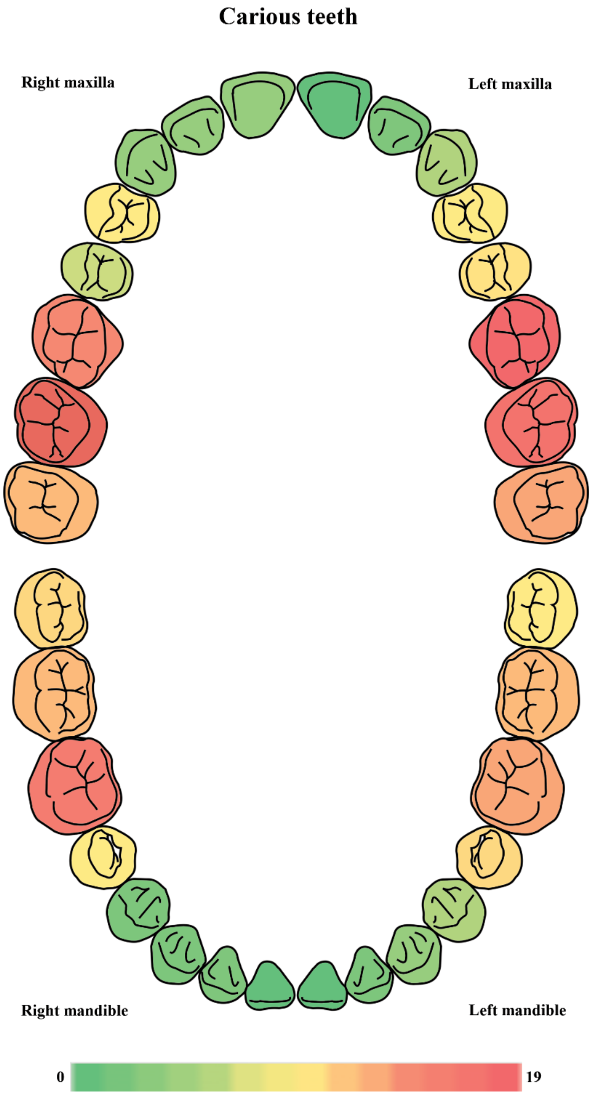


Figure 6.8: Heat map demonstrating the frequency of teeth with caries on individual morphological tooth types for the entire dental arcade. Green shades indicate little to no presence, whereas red shades indicate higher prevalence.

Table 6.4: Overall frequency for carious lesion location, orientation, and type on the tooth surface. All observations were macroscopic and could only be recorded when an emerging lesion had perforated the outer enamel or exposed cementum surface. [Table continues on subsequent page.]

Carious lesion locations			**Location**				**Orientation**							**Type**
			Coronal	CEJ†	Root	Total	Buccal	Lingual	Distal	Mesial	Occlusal	Gross	Total	Interproximal
Sex	Female	n	27	51	0	78	3	0	29	26	16	4	78	14
		%	12	22	0	33	1	0	12	11	7	2	33	6
	Male	n	45	70	1	116	3	1	37	44	22	9	116	12
		%	19	30	0	50	1	0	16	19	9	4	50	5
	Indeterminate	n	17	22	0	39	5	0	12	11	10	1	39	8
		%	7	9	0	17	2	0	5	5	4	0	17	3
	Total	n	89	143	1	233	11	1	78	81	48	14	233	34
		%	38	61	0.4	100	5	0.4	33	35	21	6	100	15
Age (adult groups)	Young Adult	n	3	3	0	6	0	0	4	2	0	0	6	2
		%	1	1	0	3	0	0	2	1	0	0	3	1
	Young/Middle Adult	n	23	26	0	49	1	1	14	15	16	2	49	4
		%	10	11	0	21	0	0	6	6	7	1	21	2
	Middle Adult	n	6	16	0	22	2	0	9	7	3	1	22	4
		%	3	7	0	9	1	0	4	3	1	0	9	2
	Middle/Old Adult	n	21	23	0	44	0	0	10	16	13	5	44	4
		%	9	10	0	19	0	0	4	7	6	2	19	2
	Old Adult	n	5	8	0	13	0	0	8	5	0	0	13	8
		%	2	3	0	6	0	0	3	2	0	0	6	3
	Indeterminate	n	31	67	1	99	8	0	33	36	16	6	99	12
		%	13	29	1	42	3	0	14	15	7	3	42	5
	Total	n	89	143	1	233	11	1	78	81	48	14	233	34
		%	38	61	0.4	100	5	0.4	33	35	21	6	100	15
Spatial	Coastal	n	75	105	1	181	5	1	61	57	44	13	181	26
		%	32	45	0	78	2	0	26	24	19	6	78	11

	Inland	n	14	29	0	43	5	0	14	19	4	1	43	8
		%	6	12	0	18	2	0	6	8	2	0	18	3
	Unknown	n	0	9	0	9	1	0	3	5	0	0	9	0
		%	0	4	0	4	0	0	1	2	0	0	4	0
	Total	n	89	143	1	233	11	1	78	81	48	14	233	34
		%	38	61	0.4	100	5	0.4	33	35	21	6	100	15
Pre/post-2000 BP	Pre-2000	n	49	74	1	124	3	1	39	40	34	7	124	16
		%	21	32	0	53	1	0	17	17	15	3	53	7
	Post-2000	n	24	51	0	75	5	0	28	29	7	6	75	12
		%	10	22	0	32	2	0	12	12	3	3	32	5
	Unknown	n	16	18	0	34	3	0	11	12	7	1	34	6
		%	7	8	0	15	1	0	5	5	3	0	15	3
	Total	n	89	143	1	233	11	1	78	81	48	14	233	34
		%	38	61	0.4	100	5	0.4	33	35	21	6	100	15
Holocene divisions	Earlier Holocene	n	17	19	0	36	0	0	9	10	16	1	36	4
		%	7	8	0	15	0	0	4	4	7	0	15	2
	Middle Holocene	n	32	55	1	88	3	1	30	30	18	6	88	12
		%	14	24	0	38	1	0	13	13	8	3	38	5
	Later Holocene	n	24	51	0	75	5	0	28	29	7	6	75	12
		%	10	22	0	32	2	0	12	12	3	3	32	5
	Unknown	n	16	18	0	34	3	0	11	12	7	1	34	6
		%	7	8	0	15	1	0	5	5	3	0	15	3
	Total	n	89	143	1	233	11	1	78	81	48	14	233	34
		%	38	61	0.4	100	5	0.4	33	35	21	6	100	15

†CEJ = cemento-enamel junction; *n* = sample size.
Totals calculated against total present lesions (*n* = 233).

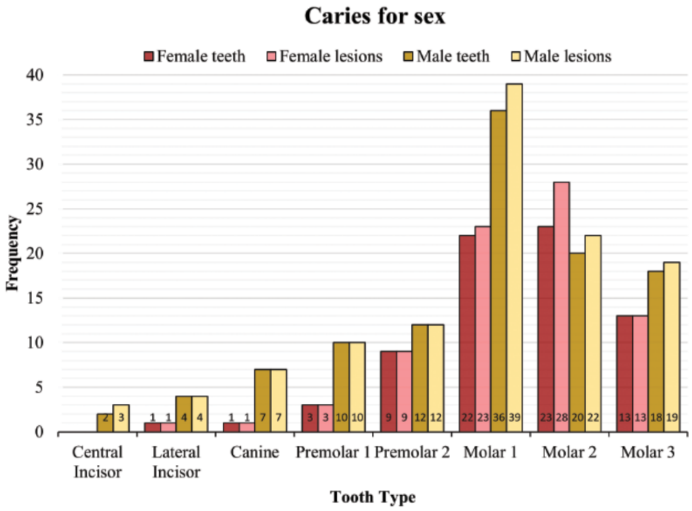
Of sexed individuals, males represented 55% (44/80), whereas females represented 45% (36/80) (Figure 6.9). Between sexes, the frequency of carious teeth and lesions on all tooth types demonstrated a similar pattern of prevalence, with frequent occurrences on the posterior teeth, particularly molars, and the fewest occurrences on the anterior teeth.

For aged individuals, most carious teeth were observed almost equally in young/middle-aged adults, with 34% (18/53) of aged carious individuals, and middle/old adults with 32% (17/53) (Figure 6.9). Carious teeth occurrence was less frequent in middle, young, and old-aged adults. Regarding age categories with substantial caries on teeth, a higher frequency of caries were observed on the posterior teeth, with consistently fewer occurrences on the anterior teeth.

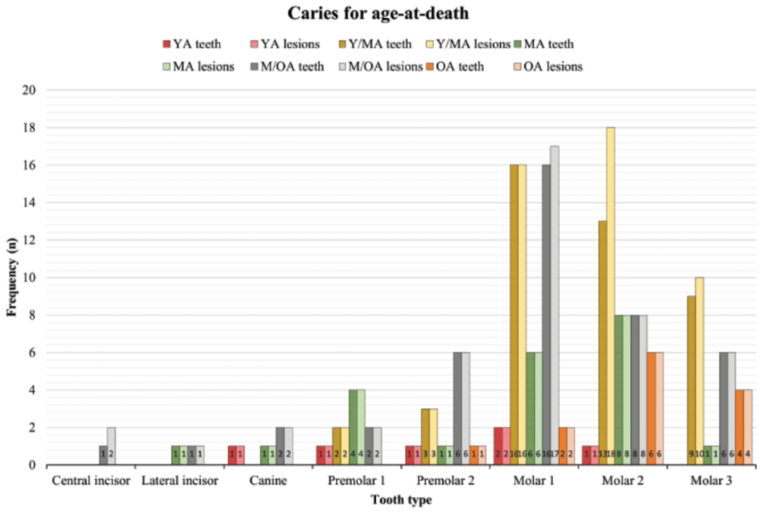
Between individuals with provenance, coastal individuals represented 82% (80/97), and inland individuals represented 18% (17/97) (Figure 6.9). Patterns of caries on tooth types between spatial regions maintained similar patterns as in other demographics; however, there were no caries observed on the central or lateral incisors for inland individuals.

Between dated individuals with caries, most dated to pre-2000 BP, representing 57% (47/82) and post-2000 BP included 43% (35/82) (Figure 6.10). Caries prevalence between pre/post-2000 BP periods followed similar patterns per tooth type as apparent on other variables; however, post-2000 BP presented no caries occurrences on the central or lateral incisors.

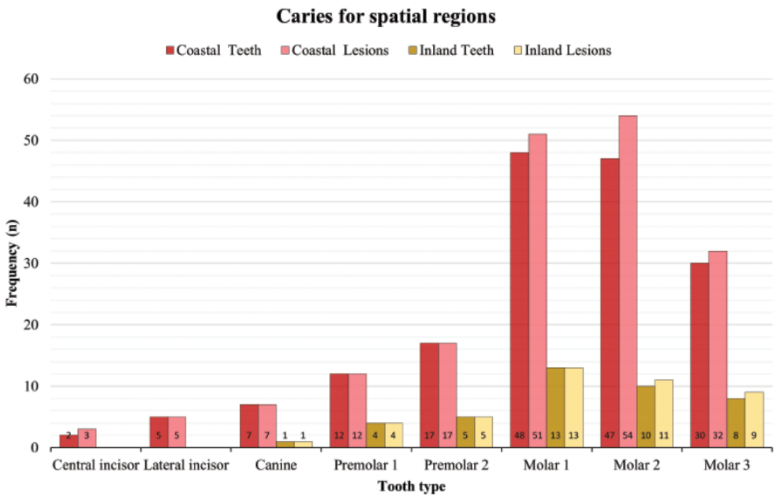
Results for Holocene divisions were similar to temporal periods, where the later Holocene included individuals with the most caries occurrences (43%; 35/82), followed by the middle Holocene (40%; 33/82), and the earlier Holocene (17%; 14/82) (Figure 6.10). Caries prevalence on tooth types occurred similarly to previous demographic examples, where the posterior teeth demonstrated the highest frequency of caries, followed by the anterior teeth. The later Holocene demonstrated no caries on the central or lateral incisors.



	Frequency of caries		
	# of Individuals	# of Teeth	# of Lesions
Variables	***n (%)***	***n (%)***	***n (%)***
Sex			
Female	36 (45)	72 (40)	78 (40)
Male	44 (55)	109 (60)	116 (60)
Total sexed	**80 (78)**	**181 (83)**	**194 (83)**
Indeterminate	22 (22)	36 (17)	39 (17)
Total	**102**	**217**	**233**

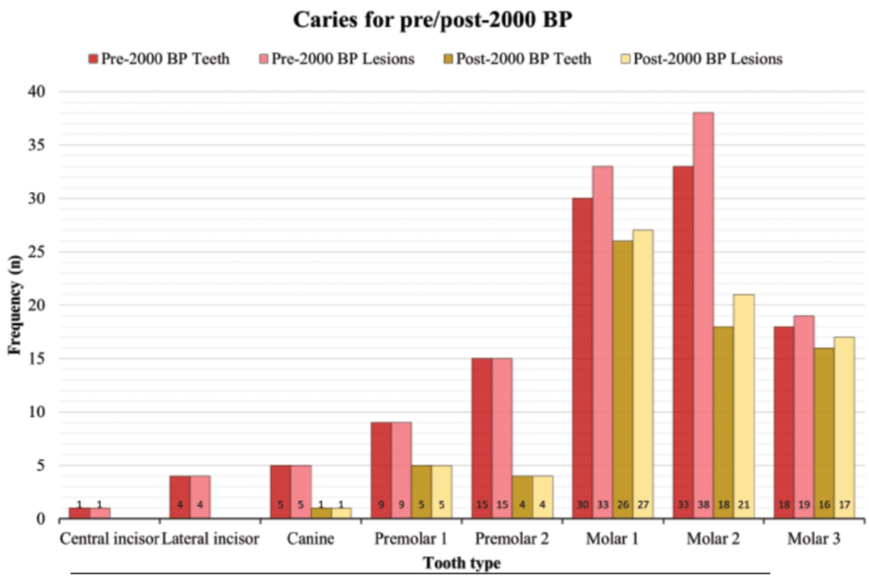


	Frequency of caries		
	# of Individuals	# of Teeth	# of Lesions
Variables	***n (%)***	***n (%)***	***n (%)***
Age-at-death estimate			
Young adult	2 (4)	6 (5)	6 (4)
Young/middle adult	18 (34)	43 (34)	49 (37)
Middle adult	11 (21)	22 (17)	22 (16)
Middle/old adult	17 (32)	42 (33)	44 (33)
Old adult	5 (9)	13 (10)	13 (10)
Total aged	**53 (52)**	**126 (58)**	**134 (58)**
Indeterminate	49 (48)	91 (42)	99 (42)
Total	**102**	**217**	**233**

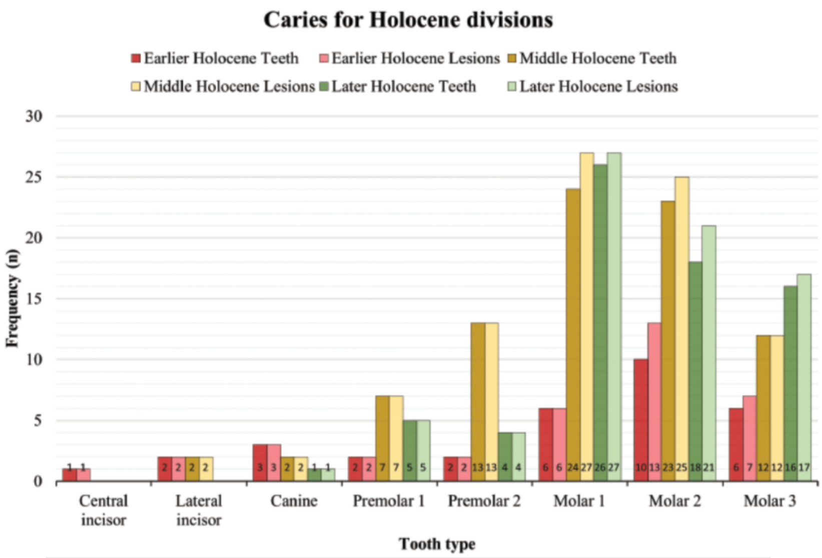


	Frequency of caries		
	# of Individuals	# of Teeth	# of Lesions
Variables	***n (%)***	***n (%)***	***n (%)***
Spatial regions			
Coastal	80 (82)	168 (80)	181 (81)
Inland	17 (18)	41 (20)	43 (19)
Total with provenance	**97 (95)**	**209 (96)**	**224 (96)**
Unknown	5 (5)	8 (4)	9 (4)
Total	**102**	**217**	**233**

Figure 6.9: Frequency of carious teeth and lesions on tooth types for demographic variables. From top to bottom: Sex, age-at-death and spatial regions. Totals and relative frequencies calculated against totals of scored variables; indeterminate/unknown frequencies calculated against the entire affected sample.



	Frequency of caries		
	# of Individuals	# of Teeth	# of Lesions
Variables	***n (%)***	***n (%)***	***n (%)***
Pre-/Post-2000 BP			
Pre-2000 BP	47 (57)	115 (62)	124 (62)
Post-2000 BP	35 (43)	70 (38)	75 (38)
Total dated	**82 (80)**	**185 (85)**	**199 (85)**
Unknown	20 (20)	32 (15)	34 (15)
Total	**102**	**217**	**233**



	Frequency of caries		
	# of Individuals	# of Teeth	# of Lesions
Variables	***n (%)***	***n (%)***	***n (%)***
Holocene divisions			
Earlier Holocene	14 (17)	32 (17)	36 (18)
Middle Holocene	33 (40)	83 (45)	88 (44)
Later Holocene	35 (43)	70 (38)	75 (38)
Total dated	**82 (80)**	**185 (85)**	**199 (85)**
Unknown	20 (20)	32 (15)	34 (15)
Total	**102**	**217**	**233**

Figure 6.10: Frequency of carious teeth and lesions on tooth types for demographic variables from top to bottom: pre/post-2000 BP and Holocene divisions. Totals and relative frequencies calculated against totals of scored variables; unknown frequencies calculated against the entire affected sample.

6.4.1 Multiple factors and their effect on caries expression

The incidence of carious teeth for tooth type and arcade was assessed using a logistic generalised linear mixed-effects regression model, with the individual term being the random effect. Initial interaction terms between tooth type and arcade were removed as none proved significant. Regarding arcade, the odds of increased caries presence in maxillae were greater than that of mandibles (OR=1.57, *p*=0.008; Figure 6.11; Table 6.5). For tooth types (Figure 6.12; Table 6.5), in comparison with central incisors, lateral incisors and canines were not appreciably different, but the odds were greater for association with caries in premolar teeth (OR=4.85 for premolar 1, *p*=0.025; OR=9.06 for premolar 2, *p*≤0.001). Molars had much greater odds of being associated with caries than central incisors, with first molars having the highest odds (OR=28.7, *p*=≤0.001), followed by second molars (OR=21.7, *p*≤0.001) and then third molars (OR=20.7, *p*≤0.001). Based on these findings, the arcade was retained for further analyses, but tooth types were collapsed into morphological categories of anterior teeth, premolars, and molars to reduce the number of factors. Collapsing the individual teeth reduced the AIC marginally from 1557.6 to 1553.3, improving the model's fit, and patterns of association were retained.

	Caries present (0)	Caries absent (1)
Mandible	0.971	0.029
Maxilla	0.96	0.04

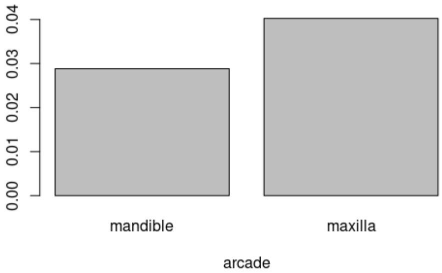


Figure 6.11: Caries probability frequencies for dental arcade.

	Caries present (0)	Caries absent (1)
Central incisor	0.9963	0.0037
Lateral incisor	0.9923	0.0077
Canine	0.9901	0.0099
Premolar 1	0.9805	0.0195
Premolar 2	0.9689	0.0311
Molar 1	0.9324	0.0676
Molar 2	0.9408	0.0592
Molar 3	0.9464	0.0536

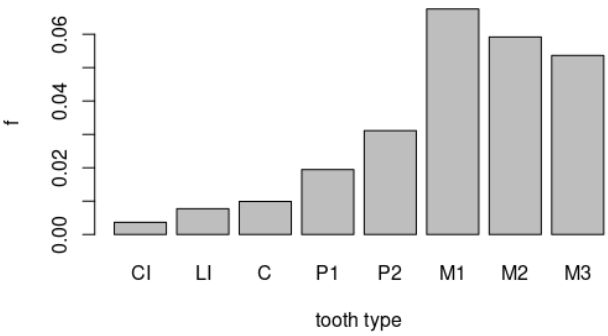


Figure 6.12: Caries probability frequencies for tooth types.

Table 6.5: Logistic regression results on effects of tooth type and arcade for caries expression. The individual (random effect) had a variance of 5.569. OR=Odds ratio; Significance levels: * ≤ 0.05, ** ≤ 0.01, *** ≤ 0.001.

Factors	Logit	OR	Std. Error	z value	P-value	
Intercept	-7.726	0.0004	0.750	-10.298	$<2\times10^{-16}$	***
Lateral incisor	0.554	1.74	0.799	0.693	0.488	
Canine	0.756	2.13	0.747	1.013	0.311	
Premolar 1	1.578	4.85	0.703	2.245	0.025	*
Premolar 2	2.204	9.06	0.687	3.206	0.001	**
Molar 1	3.357	28.7	0.672	4.996	5.86×10^{-7}	***
Molar 2	3.075	21.7	0.672	4.576	4.73×10^{-6}	***
Molar 3	3.030	20.7	0.681	4.450	8.60×10^{-6}	***
Maxilla	0.451	1.57	0.169	2.666	0.008	**

Models were rerun to assess the effect of numerous different factors on carious teeth expression. The fixed factors included the collapsed morphological tooth groups, arcade, estimated age-at-death, estimated sex, temporal allocation (pre/post-2000 and Holocene divisions), and whether the individual was inland or coastal. The results demonstrated in Table 6.6 only suggested age-at-death as potentially important where old adult individuals were associated with greater odds (OR=41.5, p=0.029) over young adults. As with the previous regression (Table 6.5), anterior dentition had reduced odds (OR=0.21, p=0.003) and molar teeth had greater odds (OR=4.42, p=≤0.001) than premolar teeth for association with caries. Moreover, maxillae had greater odds (OR=1.80, p=0.014) than mandibles.

	Caries present (0)	Caries absent (1)
Young adult	0.9707	0.0293
Young/middle adult	0.9695	0.0305
Middle adult	0.9695	0.0305
Middle/old adult	0.9558	0.0442
Old adult	0.9085	0.0915

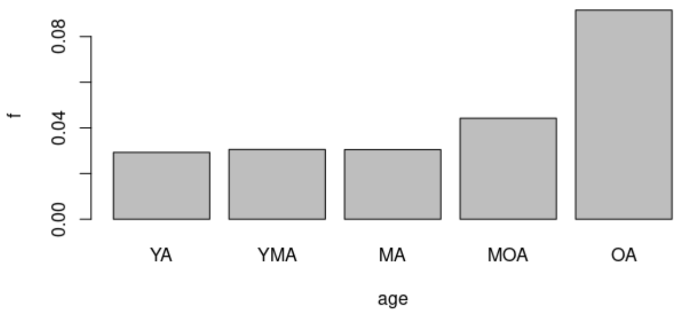


Figure 6.13: Caries probability frequencies in age-at-death groups.

Table 6.6: Logistic regression results on effects of multiple factors for caries expression. The individual (random effect) had a variance of 5.255. OR=Odds ratio; Significance levels: * ≤ 0.05, ** ≤ 0.01, *** ≤0.001; † the lack of appreciable temporal effect was reiterated when split into earlier, middle and later Holocene.

Factors	Logit	OR	Std. Error	z value	P-value	
Intercept	-7.732	0.0004	1.448	-5.338	9.39×10^{-8}	***
Anterior	-1.546	0.21	0.523	-2.953	0.003	**
Molar	1.486	4.42	0.302	4.925	8.44×10^{-7}	***
Maxilla	0.589	1.8	0.240	2.457	0.014	*
Young/middle adult	1.415	4.12	1.393	1.016	0.310	
Middle adult	1.720	5.58	1.428	1.205	0.228	
Middle/old adult	2.079	7.9	1.434	1.450	0.147	
Old adult	3.725	41.5	1.709	2.180	0.029	*
Pre2000†	0.261	1.3	0.563	0.464	0.643	
Male	-0.115	0.89	0.531	-0.216	0.829	
Inland	-0.079	0.92	0.697	-0.114	0.909	

6.4.2 Caries discussion

Caries were prevalent in 28% (102/369) of individuals, where 217 teeth were carious, and 233 carious lesions were recorded. The molars were affected ahead of the premolars, followed by the anterior teeth. Gibbon and Davies (2020) reported caries in 52% (53/102) of individuals, which far surpassed this study's frequencies. Sealy and colleagues (1992) reported caries on just over 17% (34/192) of sAHGH individuals, which subceed the results in this thesis. These patterns likely represent differences in data set composition between studies. This thesis had more individuals and more teeth, which decreased the degree of caries prevalence and increased the chances of including individuals with the minimum number of teeth required (≥3 teeth per individual). Alternatively, the frequency of AMTL may also affect collected caries rates in the sample (Esclassan, Grimoud, et al., 2009).

Of all analysed teeth, 3.5% (217/6271) had a carious lesion which is within the range of 1 - 5% for caries in HGH economies, as reported by Towle and colleagues (2021). Collapsed tooth types into morphological tooth groups exhibited four times greater odds for molar teeth with present caries (OR=4.42, $p\leq0.001$) than any other morphological tooth group. This result met expectations considering molar teeth are typically affected by caries ahead of the other teeth (Hillson, 2001). Between individual molars, the first molar was the tooth impaired most frequently by a lesion (30%; 65/217), where the odds were almost 29 times greater (OR=28.7,

$p \leq 0.001$) than carious lesion presence on central incisors, which correlates with first molar early eruption and resultant rapid exposure to cariogenesis (Esan & Schepartz, 2018). Caries on anterior teeth are atypical in HGH individuals, where some local and global HGH studies have noted incidence rates of zero for anterior caries (Kelley et al., 1991; Schneider, 1986; Sealy et al., 1992). Heavy dental wear affected all teeth of the sAHGH dentition; therefore, the expectation that the third molar should be at greater risk for caries due to the extended retention of the occlusal surface fissures from late eruption (Morris, 1992a) was not met. The third molar did not exhibit higher caries rates than its molar counterparts, and these teeth demonstrated the fewest frequency of occlusal caries (n = 21) compared to the second (n = 47) and first (n = 36) molars. It is inferred that occlusal surfaces likely did not inhibit sAHGH cariogenesis, even before they wore down to the dentine surface. This is discussed further with all observed variables in Chapter 7.

Maxillary teeth were affected (59%, 127/217) ahead of mandibular teeth (41%, 90/217). This observation was significant, and the odds of caries on maxillae were 1.5 times greater (OR=1.57, p=0.008) than on mandibles. Upper and lower teeth can vary in susceptibility to dental caries, mainly due to their differing eruption time and the anatomy of each morphological tooth type (Macek et al., 2003), as well as sociocultural factors between populations that affect caries production, such as diet type and food processing techniques (Temple, 2016). Authors have reported disparate results, for example, Hillson (2001) indicated lower teeth to be more susceptible to caries, whereas a clinical study by Demirci and colleagues (2010) reported upper teeth as more susceptible. In these results, AMTL also exhibited appreciable results where maxillae were affected ahead of mandibles. This correlation regarding caries is essential when considering the concerns that introduced the caries correction factor into bioarchaeological studies (Lukacs, 1995). If the maxillary teeth have significant odds of demonstrating AMTL, then the researcher can only determine a proportion of observable dental disease on a tooth with what skeletal material is available. Notably, all present teeth in the entire sample were included in generalised linear models for the regression to account for all possible instances for presence and absence of caries, which meant any present dental disease on an absent tooth was impossible to record yet all the present teeth were included as a “caries absent” factor in the model and AMTL would not be corrected for and may influence the statistics in the archaeological sample. sAHGH literature has not yet reported carious teeth separated by the upper and lower dental arcades; therefore, these results suggested a greater prevalence of carious lesions on maxillary teeth for sAHGH populations.

There was an expectation of observing caries more frequently at the CEJ, potentially due to heavy wearing eliminating grooves and fissures. These data met this expectation considering 61% (143/233) of total carious lesions were located at the CEJ, and occlusal lesions represented 21% (48/233) of all lesions. Otherwise, lesions occurred most frequently on the mesial surface, closely followed by the distal surface (35% and 33%, respectively). Similarly, Gibbon and Davies (2020) reported that lesion location predominantly affected the CEJ and occlusal surfaces. Occlusal surfaces have been considered common areas for caries in contemporary populations (Demirci, Tuncer & Yuceokur, 2010), and when regarding HGH populations with heavier wear, it has been contested that grooves and fissures on the occlusal surface wear away; thus, caries will favour the approximal regions (Larsen, 2015). Approximal regions being affected ahead of occlusal surfaces were reflected in this study sample considering mesial and distal surfaces had more carious lesions than occlusal surfaces. Approximal surfaces become common areas for caries due to tight spaces ideal for bacterial growth between adjacent teeth, exacerbated by the development of calculus deposits (Hillson, 2001).

6.4.2.1 Caries and demographics

Although the effect was insignificant, males exhibited more carious teeth (n = 109) and lesions (n = 116) than females (n = 72, n = 78, respectively), which opposed expectations for caries being more prevalent in sAHGH females (Sealy & van der Merwe, 1988). Research has suggested that female sAHGH individuals 'snacked' during gathering expeditions, which catalysed female sAHGH caries development (Sealy et al., 1992). El-Zaatari (2010) assessed sAHGH microwear and presented few and insignificant microwear mark differences for fibrous plant consumption between various demographic categories, including sex. Although 'snacking' may still have been a behavioural aspect amongst some female sAHGH, these results did not support this behaviour occurring at a significant enough rate to contribute to cariogenesis favouring female dentition. The lack of significance for sexual dimorphism may instead correspond with ethnographic accounts of 'group sharing', wherein access to resources was distributed equally between genders of a single tribe or family (Lee, 1979; Lukacs, 1992; Boonzaier et al., 1996).

Old-aged adults demonstrated significantly greater odds (OR=41.5, p=0.029) of caries presence than all other age categories. These data supported general age-related patterns on caries progression throughout life, as discussed by Hillson (2001), where there tends to be a progressive rise in carious lesion development in each subsequent age category. The skewed sample distribution for age categories with fewer individuals in young and old adult categories is worth noting, as observations on caries presence between age estimates should be exercised with caution.

Coastal individuals (82%, 80/97) far outweighed inland individuals (18%; 17/97) for caries occurrence due to the biased sample distribution, although the result remained insignificant. Sealy and colleagues (1992) reported 2.6% of analysed coastal teeth to be carious, which aligned with the results from this study with 2.7% (168/6271) of carious teeth when the frequency is calculated against all present teeth (n = 6271) as opposed to overall carious teeth (n = 217). The inland results from Sealy and colleagues (1992) were markedly different (8.7%) compared to the results from this study (0.65%; 41/6271) when calculated without a caries correction factor (against all present teeth); however, they reported their results from a single site that included five individuals and were also subject to bias as were the spatial results from this thesis.

Between pre/post-2000 BP, individuals dating to pre-2000 BP demonstrated the highest frequency of carious individuals (57%, 47/82) compared to post-2000 BP (43%, 35/82). Similar to temporal results for AMTL, when dissecting the divisions further, individuals with caries in the later Holocene (43%, 35/82) were nearly equal to the middle (40%, 33/82) Holocene; yet the number of teeth with caries in the middle Holocene (45%, 83/185) outweighed the later Holocene (70%, 70/185) for both carious teeth and lesions. Black (2014) similarly reported that caries occurred more frequently in the middle Holocene. These results demonstrated that the middle Holocene, although with fewer individuals with caries, had more caries per individual on all tooth types. This is likely a multifactorial effect: reflective of sample bias, selective groups increasing carbohydrate intakes such as those in forest and fynbos biomes (Stock & Pfeiffer, 2004), or poor population-wide health from population expansion (Pfeiffer & Sealy, 2006) rendering the stressed physical body susceptible to further pathology (DeWitte & Bekvalac, 2010).

6.4.2.2 Environmental and resistance factors in the aetiology of caries

The intensity of environmental factors being low compared to a higher presence of resistance factors or a tooth's predisposition to caries results in little observable change in the prevalence of caries (Davies, 1963), particularly in HGH populations whose behaviour is environmentally dependent. Davies (1963) suggested that in some cases, fewer environmental factors predisposing the teeth to caries (e.g., protein-rich diet, high fluoride) may result in minor changes in resistance to caries development and significant changes in caries prevalence.

An aspect of resistance change was apparent in this sample when regarding spatial provenances from the southeastern Cape. Individuals with provenance from this general region, namely from Knysna, Oakhurst (rock shelter), Matjies river, or Nelson Bay Cave, were notable in both archaeological and contemporarily relevant literature due to isolated examples of high caries frequency as a result of low water fluoride of below 2ppm (Ockerse, 1943; Grobler & Dreyer, 1988; Patrick, 1989; Sealy et al., 1992). From these sites, 14 of the 21 individuals presented with carious lesions, where the highest lesion count in this group and the entire sample was eight carious lesions (UCT 347). The mean lesion count for the entire sample was 2.3 per individual, yet the mean for the 14 individuals from the south-eastern Cape sites was 3.4 lesions. It may be inferred that several individuals' resistance factors were reduced in these spatial regions due to the low fluoride content of the surrounding drinking water, reflected by a steep rise in caries occurrence. Notably, the caries frequency was relatively equal overall between demographic groupings when assessing all individuals. These data suggest that the entire sAHGH population remains relatively homogenous, where any isolated differences observed in the sample were observable on a smaller scale and likely due to environmental (low fluoride) or adverse (rapid population growth) but not overarching behavioural dissimilarities (Davies, 1963; Morris, 1992a). A heterogenous HGH population would be reflected in global studies by significant variation in carious frequency associated with dietary changes between demographics (Costa, 1980).

6.5 Infectious lesions

All infectious lesions in this sample were diagnosed macroscopically; therefore, lesions had to perforate the cortical bone. Where possible, loose teeth with preserved sockets were carefully removed to examine the alveolar socket for additional infectious lesions. It must be noted that infectious lesions were scored later in the study on a reduced sample size (n = 266 total individuals, n = 4827 total teeth) due to methodological errors in initial data collection. Figure 6.1 demonstrated the frequency of infectious lesions for each tooth type. Observable infectious lesions were diagnosed on 24% (65/266) of total individuals, and 3% (153/4827) of present teeth were associated with an infectious lesion, with 157 total lesions recorded.

Maxillae had 65% (99/153) of teeth associated with an infectious lesion, and mandibles had 35% (54/153). When comparing the anterior and posterior teeth, the posterior teeth were more prone to association with infectious lesions than the anterior teeth. Of all teeth showing evidence of association with a lesion, the first molars were affected most frequently (30%; 46/153). The second-most affected tooth type were the second premolars (15%; 23/153), closely followed by the first premolars (14%; 22/153). The third molars were the least affected tooth types, with 6% (9/153). Infectious lesions associated with the anterior teeth were less frequent but, where prevalent, were most frequently observed with maxillary central incisors (10%; 10/99) of total maxillary teeth associated with an infectious lesion, or on mandibular canines, with 11% (6/54) of total mandibular teeth associated with an infectious lesion.

On all 4827 teeth scored for infectious lesions, there were 153 teeth associated with an infectious lesion, but 157 overall lesions were recorded. The type of lesion may only be diagnosed by observation of physical characteristics and lesion size measured in millimetres. Overall, 20% (31/157) were diagnosed as a ≤3mm cyst, 43% (67/157) as a >3mm cyst, 8% (5/157) as a primary, chronic abscess, and 51% (32/157) as chronic osteomyelitis. Of all macroscopically visible infectious lesions, there were eight observable fistulae. Regarding the directions of the visible lesions, 89% (140/157) were observed on the lateral (external) surface of the alveolar body, 7% (11/157) on the medial (internal) surface, and 4% (6/157) were in interproximal spaces on the alveolar bone.

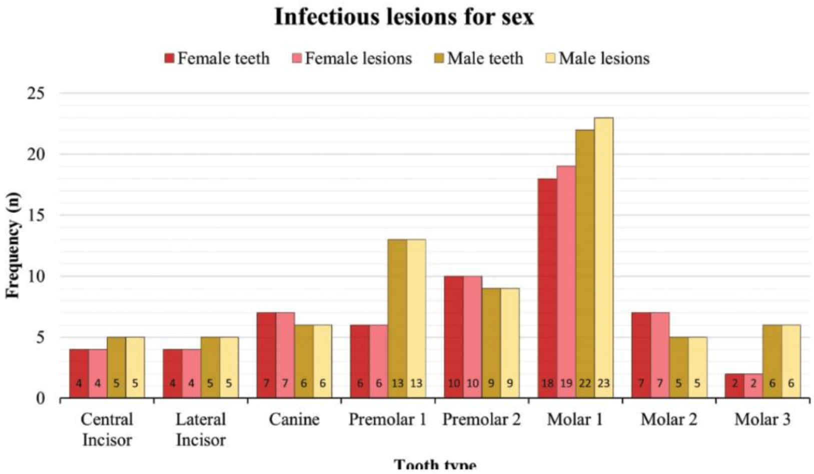
For sexed individuals, male and female infectious lesion distribution was almost equal, where males had 51% (71/129) of teeth from sexed individuals associated with a lesion, and females had 49% (58/129) (Figure 6.14). Tooth types affected were relatively consistent between sex, though the largest difference between sexes was observed with the second molars, where females had 12% (7/58) of total female teeth associated with an infectious lesion compared to males with 7% (5/71).

For aged individuals, young/middle adults were most frequently affected (41%; 16/39), compared to young adults being the fewest affected (3%; 1/39) (Figure 6.14). Between almost all age categories, the first molars were most frequently associated with infectious lesions, except for middle/old adults, of which lateral incisors and first premolars, both with 19% (4/21) of total middle/old adult teeth, were predominantly affected ahead of the molars.

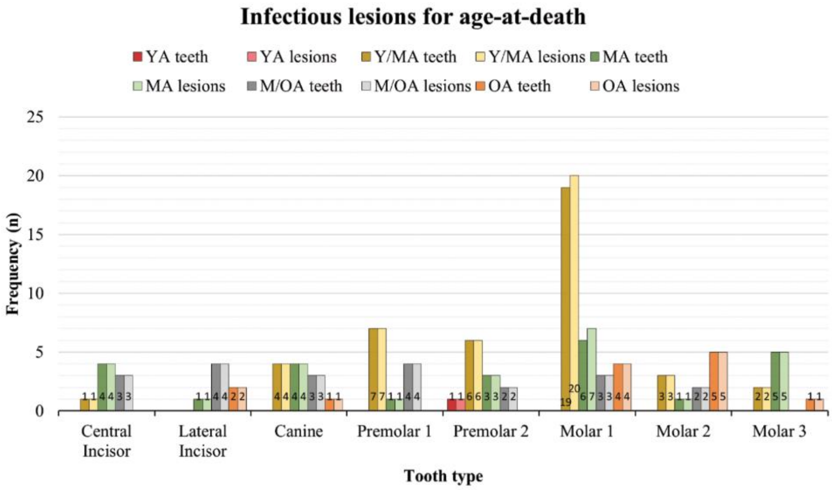
Most individuals with infectious lesions and provenance were from the coast (89% 56/63) compared to inland (11%; 7/63) (Figure 6.14). In coastal teeth, first molars were most frequently affected (27%; 36/131). In inland individuals, the patterns of teeth associated with infectious lesions were similar, except for the first molars representing a larger total of 50% (9/18).

Dated individuals with an infectious lesion were distributed equally between pre/post-2000 BP, each representing 50% (29/58) (Figure 6.15). Regarding the frequency of teeth associated with an infection lesion, 55% (77/140) of pre-2000 BP teeth were observed with lesions compared to post-2000 BP with 45% (63/140). Pre-2000 BP had higher frequencies of infectious lesions on first molars (26%; 20/77) and both premolars (22%; 17/77). Although the first molars represented the highest frequencies in post-2000 BP teeth (40%; 25/63), the incisors presented 10% (6/63) of teeth associated with infectious lesions, ahead of the first and second premolars, 8% (5/63) and 6% (4/63), respectively.

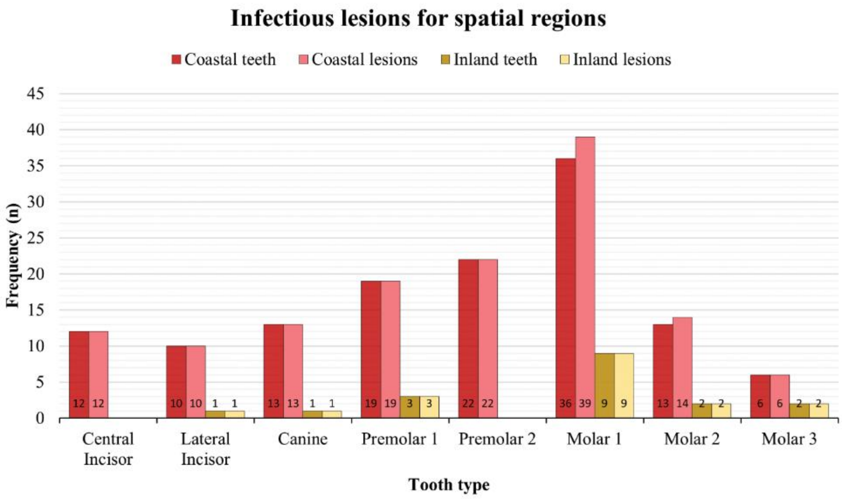
Holocene divisions demonstrated an almost equal distribution of individuals with an infectious lesion between the middle (43%; 25/58) and later Holocene (50%; 29/58), and the earlier Holocene had the fewest individuals (7%; 4/58) (Figure 6.15). Between Holocene divisions, the first molars exhibited the highest frequency of teeth associated with infectious lesions; however, between the middle and later Holocene, the premolars were affected more frequently in the middle Holocene (43%; 30/69) compared to the later Holocene (14%; 9/63). The earlier Holocene had few teeth associated with infectious lesions, exhibiting 6% (8/140) total affected teeth.



	Frequency of infectious lesions		
	# of Individuals	# of Teeth	# of Lesions
Variables	***n (%)***	***n (%)***	***n (%)***
Sex			
Female	26 (49)	58 (45)	59 (45)
Male	27 (51)	71 (55)	72 (55)
Total sexed	**53 (82)**	**129 (84)**	**131 (83)**
Indeterminate	12 (18)	24 (16)	26 (17)
Total	**65**	**153**	**157**

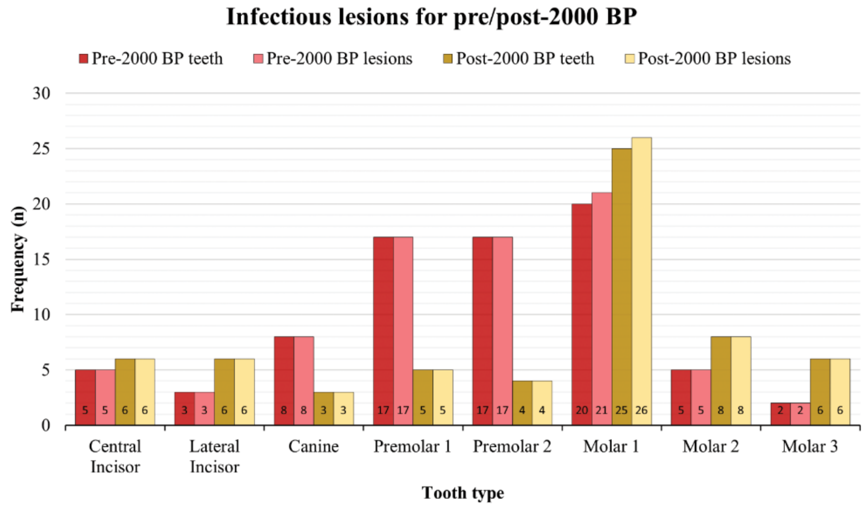


	Frequency of infectious lesions		
	# of Individuals	# of Teeth	# of Lesions
Variables	***n (%)***	***n (%)***	***n (%)***
Age-at-death estimate			
Young adult	1 (3)	1 (1)	1 (1)
Young/middle adult	16 (41)	42 (41)	43 (41)
Middle adult	9 (23)	25 (25)	26 (25)
Middle/old adult	9 (23)	21 (21)	21 (20)
Old adult	4 (10)	13 (13)	13 (13)
Total aged	**39 (60)**	**102 (67)**	**104 (66)**
Indeterminate	26 (40)	51 (33)	53 (34)
Total	**65**	**153**	**157**

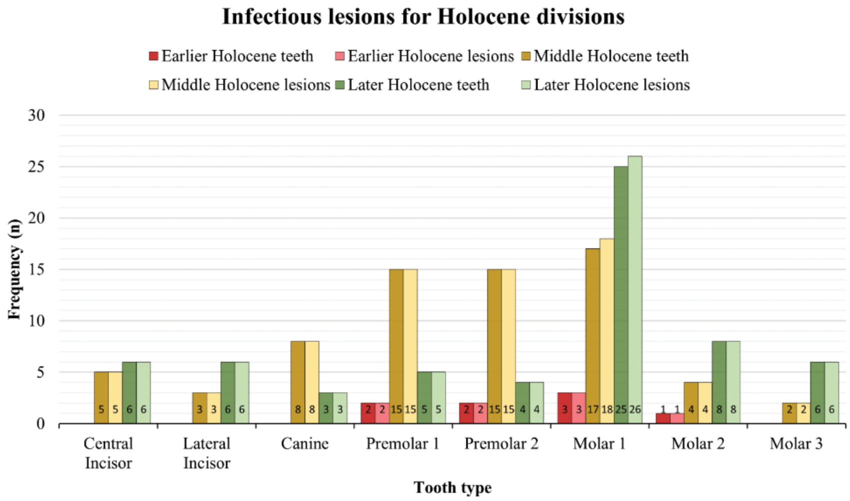


	Frequency of infectious lesions		
	# of Individuals	# of Teeth	# of Lesions
Variables	***n (%)***	***n (%)***	***n (%)***
Spatial regions			
Coastal	56 (89)	131 (88)	135 (88)
Inland	7 (11)	18 (12)	18 (12)
Total with provenance	**63 (97)**	**149 (97)**	**153 (97)**
Unknown	2 (3)	4 (3)	4 (3)
Total	**65**	**153**	**157**

Figure 6.14: Frequency of teeth associated with an infectious lesion and number of lesions associated with tooth types for demographic variables. From top to bottom: sex, age-at-death and spatial regions. Totals and relative frequencies calculated against totals of scored variables; indeterminate/unknown frequencies calculated against the entire affected sample.



	Frequency of infectious lesions		
	# of Individuals	# of Teeth	# of Lesions
Variables	***n (%)***	***n (%)***	***n (%)***
Pre-/Post-2000 BP			
Pre-2000 BP	29 (50)	77 (55)	78 (55)
Post-2000 BP	29 (50)	63 (45)	64 (45)
Total dated	**58 (89)**	**140 (92)**	**142 (90)**
Unknown	7 (11)	13 (8)	15 (10)
Total	**65**	**153**	**157**



	Frequency of infectious lesions		
	# of Individuals	# of Teeth	# of Lesions
Variables	***n (%)***	***n (%)***	***n (%)***
Holocene divisions			
Earlier Holocene	4 (7)	8 (6)	8 (6)
Middle Holocene	25 (43)	69 (49)	70 (49)
Later Holocene	29 (50)	63 (45)	64 (45)
Total dated	**58 (89)**	**140 (92)**	**142 (90)**
Unknown	7 (11)	13 (8)	15 (10)
Total	**55**	**153**	**157**

Figure 6.15: Frequency of teeth associated with an infectious lesion and number of lesions associated with tooth types for demographic variables. From top to bottom: pre/post-2000 BP and Holocene divisions. Totals and relative frequencies calculated against totals of scored variables; unknown frequencies calculated against the entire affected sample.

6.5.1 Multiple factors and their effect on infectious lesion expression

The incidence of infectious lesions associated with tooth type and arcade was assessed using a logistic generalised linear mixed-effects regression model, with the individual term being the random effect. Initial interaction terms between tooth type and arcade were eliminated as they were insignificant. There were 3441 total observations. Regarding the arcade, the odds of infectious lesions in maxillae were greater than in mandibles (OR=1.76, p=0.002; Figure 6.16; Table 6.7). For tooth types (Figure 6.17, Table 6.7), in comparison with central incisors, lateral incisors, canines, premolars, second molars, and third molars were not appreciably different, but the odds were greater for association with infectious lesions in first molars (OR=4.44, $p\leq 0.001$). Based on these findings, the arcade was retained for further analyses, but tooth types were collapsed into morphological categories of anterior teeth, premolars, and molars to reduce the number of factors. Collapsing the individual teeth reduced the AIC marginally from 1266.2 to 799.6, improving the model's fit, and the patterns of association were retained for the arcade but not for tooth types.

	Infectious lesion present (0)	Infectious lesion absent (1)
Mandible	0.9835	0.0165
Maxilla	0.9725	0.0275

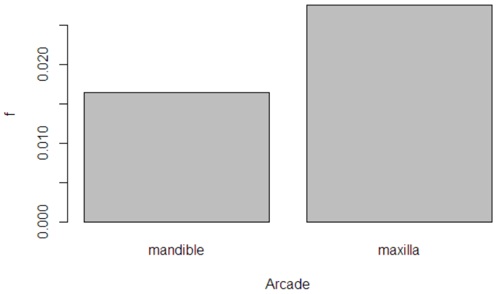


Figure 6.16: Infectious lesion probability frequencies for dental arcade.

	Infectious lesion present (0)	Infectious lesion absent (1)
Central incisor	0.9858	0.0142
Lateral incisor	0.9873	0.0127
Canine	0.9842	0.0158
Premolar 1	0.9753	0.0247
Premolar 2	0.9735	0.0265
Molar 1	0.9471	0.0529
Molar 2	0.9815	0.0185
Molar 3	0.9884	0.0116

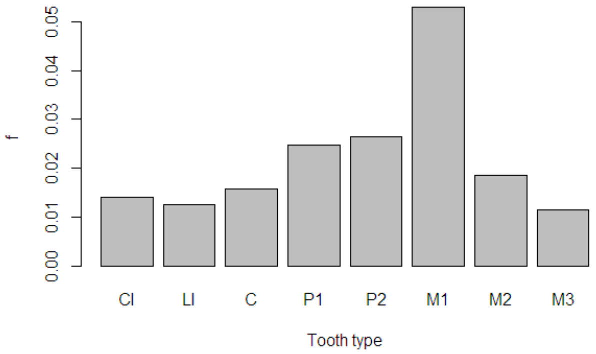


Figure 6.17: Infectious lesion probability frequencies by tooth types

Table 6.7: Logistic regression results on effects of tooth type and arcade on infectious lesion expression. The individual (random effect) had a variance of 4.121. OR=Odds ratio; Significance levels ≤ 0.1, * ≤ 0.05, ** ≤ 0.01, *** ≤0.001.

Factors	Estimate	OR	Std. Error	z value	P-value	
Intercept	-6.21833	0.002	0.46224	-13.453	$<2\times10^{-16}$	***
Lateral incisor	-0.18252	0.83	0.42990	-0.425	0.67115	
Canine	0.06245	1.06	0.40581	0.154	0.87769	
Premolar 1	0.57659	1.78	0.37245	1.548	0.12160	
Premolar 2	0.65820	1.93	0.37011	1.778	0.07534	.
Molar 1	1.49030	4.44	0.33898	4.396	1.1×10^{-5}	***
Molar 2	0.23811	1.27	0.39512	0.603	0.54676	
Molar 3	-0.28002	0.76	0.45411	-0.617	0.53747	
Maxilla	0.56256	1.76	0.18589	3.026	0.00248	***

Regressions were performed again to assess the effect of several factors on the association of teeth and infectious lesions (Table 6.8). The fixed factors included the collapsed morphological tooth groups, arcade, estimated age-at-death, estimated sex, temporal allocation of pre/post-2000 BP, and whether the individual was inland or coastal. As with the previous regression (Table 6.7), maxillae had greater odds (OR=2.15, $p\leq0.001$) than mandibles; however, no other factor proved significant for collapsed morphological tooth groups nor demographic factors.

Table 6.8: Logistic regression results on the effects of multiple factors on the expression of infectious lesions. OR=Odds ratio. The individual (random effect) had a variance of 3.044. Significance levels: * ≤ 0.05, ** ≤ 0.01, *** ≤0.001. † The lack of appreciable temporal effect was reiterated when separated into earlier, middle and later Holocene.

Factors	Estimate	OR	Std. Error	z value	P-value	
Intercept	-6.5051	0.001	1.3186	-4.933	$8.09\text{x}10^{-7}$	***
Anterior	-0.3595	0.7	0.3006	-1.196	0.231821	
Molar	0.4279	1.53	0.2674	1.600	0.109615	
Maxilla	0.7649	2.15	0.2286	3.346	0.000819	***
Young/middle adult	1.1867	3.28	1.2948	0.917	0.359386	
Middle adult	1.2319	3.43	1.3244	0.930	0.352301	
Middle/old adult	1.0097	2.75	1.3525	0.747	0.455327	
Old adult	2.4462	11.55	1.4996	1.631	0.102829	
Pre2000†	-0.4067	0.67	0.4923	-0.826	0.408775	
Male	0.3966	1.49	0.4708	0.842	0.399635	

6.5.2 Infectious lesion discussion

Infectious lesions were diagnosed on the alveolus, where the presence of a tooth was redundant; however, for clarity of lesion location and considering infections are often associated with a tooth, the lesions were recorded in association with the nearest tooth. As a result, only lesion counts were recorded. Macroscopic observations of infectious lesions affected 24% (65/266) of the sample and 3% (152/4827) of present teeth, where Gibbon and Davies (2020) similarly reported macroscopic infectious lesions through abscesses or periapical infections in 30% (45/150) of sAHGH individuals. Maxillae exhibited more infectious lesions than mandibles (OR=1.76, p=0.002), which met expectations, particularly with the development of advanced apical cysts as were observed in this sample (Dias, Prasad & Santos, 2007). The frequency of maxillary infectious lesions was likely associated with heavy dental wear in the maxillary teeth, in addition to the teeth demonstrating significantly greater odds in oblique and plane wear, where both heavy and asymmetric wear would rapidly expose the pulp chamber of single-cusped teeth as they wear at an angle (Grimoud & Gibbon, 2017). Maxillary teeth affected by infectious lesions may consequently infiltrate the thin sinus floor, resulting in systemic consequences for some individuals, including complications in the ethmoid, frontal, and sphenoid sinuses (Forshaw, 2014). Infectious lesions were significantly more prevalent with the first molar (OR=4.44, $p \leq 0.01$) than any other tooth type, which is likely due to the tooth's increased proneness to conditions such as caries, which may infect the pulp cavity. Since anterior teeth demonstrated the most significant probability of pulp chamber exposure ahead of any other tooth groups, interestingly, the anterior teeth were not as frequently associated with infectious lesions in this sample compared to molars. An explanation may be related to maxillary anterior teeth exhibiting frequent AMTL; therefore, single-rooted teeth may have already been lost before an infection developed (Scott, 2020).

6.5.2.1 Infectious lesions and demographics

Although insignificant, males had more teeth associated with infectious lesions (55%; 71/129) than females (45%; 58/129), which correlated with caries results. The female second molar demonstrated slightly more association with infectious lesions, which can correlate with dental trauma, as female second molars also exhibited higher incidence rates for dental trauma than males. Modest microchips and cracks largely represented dental trauma; however, a study by Kieser and colleagues (2001) reported infectious lesions might occur in teeth with no other evidence of pulpal or dentine exposure. The authors noted that periapical infections may develop through bacterial entry in macroscopically visible and invisible enamel and dentine cracks. Additionally, trauma to a tooth in the form of root luxation can affect the supply of blood to the pulp chamber, which may result in pulpal necrosis and resultant infections, even if the tooth appears macroscopically asymptomatic (Öztan & Sonat, 2001; Forshaw, 2014).

Young/middle, middle, and middle/old-aged adults exhibited the most infectious lesions (41%, 16/39; 23%, 9/39; 23%, 9/39; respectively), and young adults comprised the fewest infected (3%; 1/39). Old-aged adults exhibited the second-fewest infectious lesions (10%; 4/39). A lack of infectious lesions in older age that have already manifested themselves in the form of abscesses is notable because an advanced degree of pulpal infection can be markedly fatal regarding additional complications that may arise (Dias & Tayles, 1997; Forshaw, 2014). Theoretically, if most old-aged adults demonstrated high frequencies of infectious lesions, particularly in an advanced stage (e.g., abscesses, osteomyelitis), the assumption would entail that most individuals lived to old age but had conditions associated with poor oral health, and lesions may have contributed to additional fatal complications (Forshaw, 2014). For example, acute infectious lesions can progress to generalised septicaemia, systemically impairing an individual's health (Uluibau, Jaunay & Goss, 2005). It is inferred that the infections occurring in and around 'middle-aged adult categories' may have been a condition associated with their mortality in the case of rapidly developing a systemic disease, whereas otherwise, as represented by the old-age cohort, sAHGH individuals also survived well into old age and still maintained seemingly good overall health (Pfeiffer, 2007; Gibbon & Davies, 2020). It is acknowledged through the osteological paradox, however, that the older individuals, which are of a smaller sample, may not represent the health of all individuals.

Between pre and post-2000 BP, the same number of individuals were affected with a visible lesion (50%, 29/58), and as previously mentioned, pre-2000 BP exhibited more lesions per individual (55%, 78/142) than post-2000 BP (45%, 64/142), although insignificantly. In particular, the middle Holocene outweighed the subsequent period for lesions located around the canines and premolars, whereas the later Holocene exhibited more lesions around the incisors and molars. The earlier Holocene had the lowest incidence rates for infectious lesions and exclusively exhibited lesions around both premolars, the first and second molars. These results corresponded with caries, AMTL, and pulp chamber exposure from dental wear. Reichart and colleagues (2007) assessed 33 skulls from Cameroon and reported that modified teeth (chipped and filed down) were associated with infectious lesions and noted that nine individuals exhibited periapical ostitis or radicular cysts around the apex of modified anterior teeth. However, the results from this thesis did not exhibit exact associations between particular tooth types and infections, where dental wear was heaviest on anterior teeth within all Holocene divisions, and otherwise followed the time of the eruption, thus not corresponding with infection results between temporal periods. Additionally, Rufino and colleagues (2017) reported on 81 archaeological enslaved Africans from Lagos, Portugal and noted a significant association of periapical lesions with intentionally modified teeth; but low incidence rates in non-masticatory markers were observed in the teeth, and no dental decoration through intentional modification was observed in this thesis. These investigations suggest that aetiological explanations are likely multifactorial and involve an interplay between oral health conditions. Poor nutrition, as was more likely in the middle Holocene from rapid population growth and resource scarcity (Pfeiffer, 2007), may have contributed to possible increased systemic dental disease and infections. These data for infectious lesions would benefit from additional radiographic examination investigations, as it may be that some lesions were not yet in a severe stage of inflammation and thus are not visible on the external borders of maxillae or mandibles (Dias & Tayles, 1997).

6.5.2.2 Non-odontogenic cysts

The observations from this study cannot confirm that tooth extraction was not an implemented technique for sAHGH individuals to prevent the development of cysts and lesions, as stated by Dias and colleagues (2007), although the lack of consistently observable patterns in AMTL as associated with infectious lesions indicated that it was an unlikely practice. Acute abscesses may result in complications, and an infectious lesion does not necessarily imply the individual was unwell. Instead, despite numerous and persisting infections, many individuals assessed in this study were healthy enough to resist additional complications following an infection (Dias & Tayles, 1997). As reflected in this thesis, the moderate number of lesions per individual support these observations, particularly in those who survived well into middle- and old age. Even untreated lesions that manifest as abscesses can drain intra-orally and do not necessarily progress to life-threatening infections (Kieser et al., 2001).

One individual (SAM-AP 32) exhibited a nasopalatine duct cyst demonstrated by an enlarged incisive fossa (Figure 6.18), in addition to the maxilla presenting multiple infectious lesions around the premolars. Nasopalatine duct cysts are common amongst non-odontogenic midline cysts (Dedhia et al., 2013) and occur following an inflammatory response, although the precise aetiology of this trigger is often unknown (McKinney & Olmo, 2022). Where the cysts appear alarming due to their size, clinical studies report them as asymptomatic, and clinicians typically uncover these cysts in routine imaging examinations (Oliveira et al., 2017).

Clinical studies recommend surgical treatment even though they may remain asymptomatic and tend to drain intraorally if left untreated. However, inadequate drainage can eventually lead to some discomfort if the lesion expands (McKinney & Olmo, 2022).

Figure 6.18: Individual (SAM-AP 32) with nasopalatine duct cyst (red arrow) enlarging the incisive fossa.

Another individual exhibited large facial cysts that may have a differential diagnosis of nasoalveolar and globulomaxillary loci, as illustrated by Gregg and colleagues (1983), as well as resultant observations of overeruption of several right mandibular teeth (Figure 6.19). Clinically, overeruption can result in possible occlusal interference, increasing wear and possible fracturing of the involved teeth (Vallon, Nilner & Kopp, 1989; Craddock & Youngson, 2004). Anterior overeruption for this individual likely occurred from AMTL of its maxillary counterparts, possibly due to the gross cysts that had developed, loosening the grip of single-rooted teeth in the socket (Scott, 2020), or due to additional but unknown factors. Apart from the infectious lesions and overeruption, the individual demonstrated no other dental pathology or complications in the mouth and was only affected with advanced wear, yet no pulp chamber exposure or necrosis in the teeth that remained. As such, some possibilities for the cyst's origins were due to neoplasms of the face, sinus infections or physical trauma (Gregg et al., 1983), which resulted in maxillary tooth loss and the overeruption of the mandibular teeth; wherein the latter condition would likely have only contributed to general inconveniences from occlusal interference with surrounding teeth (Craddock & Youngson, 2004).

Figure 6.19: Individual (UCT 120) with (A) nasoalveolar and globulomaxillary non-odontogenic cysts and (B) Overeruption of right mandibular lateral incisor, canine and first premolar as a result of maxillary tooth loss likely from the associated infectious lesions.

These examples of non-odontogenic cysts, reportedly common in contemporary research (Dedhia et al., 2013; McKinney & Olmo, 2022), were not frequently acknowledged in palaeopathological literature despite their presence (D'Anastasio et al., 2022), as evidenced by this thesis presenting the condition of these individuals for the first time in sAHGH research. Nevertheless, global research has widely discussed that an individual can present with cysts and abscesses without a visible source of infection (i.e., pulpal exposure) (Dias & Tayles, 1997; Ortner, 2003; Dias, Prasad & Santos, 2007; Rufino, Ferreira & Wasterlain, 2017). Although prevalent and critical to note, the infectious lesions observed in these data may not necessarily have direct associations with other dental pathology but are of independent relevance to the general condition and resilience of sAHGH.

6.6 Enamel hypoplasia

EH was diagnosed on 15% (55/369) of all analysed individuals and 3% (181/6271) of teeth present, with 201 hypoplastic defects recorded in total (Figure 6.1 and 6.21). It was more frequent on maxillae than mandibles, 59% (107/181) and 41% (74/181), respectively. EH on each tooth type varied throughout the dental arcade, and in anterior teeth, canines demonstrated the highest frequency with 23% (42/181) of total teeth with EH. In posterior teeth, the second molars demonstrated the highest frequency with 17% (30/181) of total hypoplastic teeth, followed by third molars and both premolars. First molars and first incisors had the fewest occurrences of all tooth types. Linear enamel hypoplasia (LEH) represented 87% (174/201) of lesions and pitting enamel hypoplasia (PEH) represented 13% (27/201) of lesions (Figure 6.20). One individual (UCT 107) was excluded from these analyses due to differential diagnoses of amelogenesis imperfecta. This individual had a high frequency of LEH and PEH on all surfaces of all present teeth, which is discussed further in the subsequent discussion section.

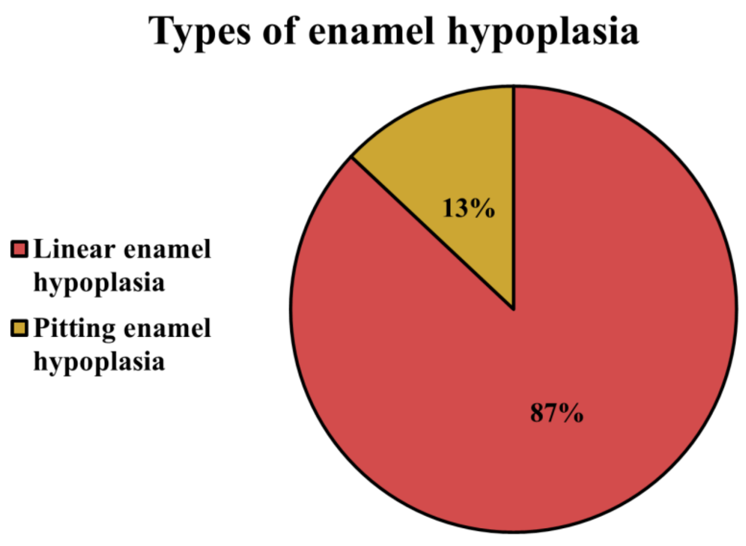


Figure 6.20: Relative frequency of types of enamel hypoplasia in this sample.

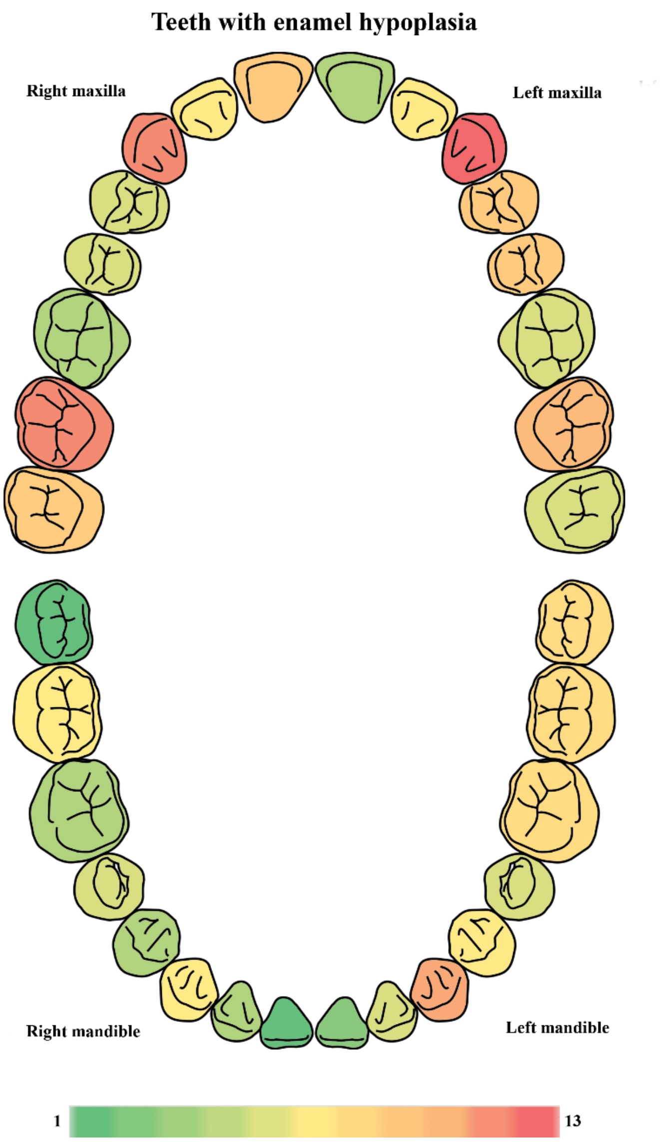


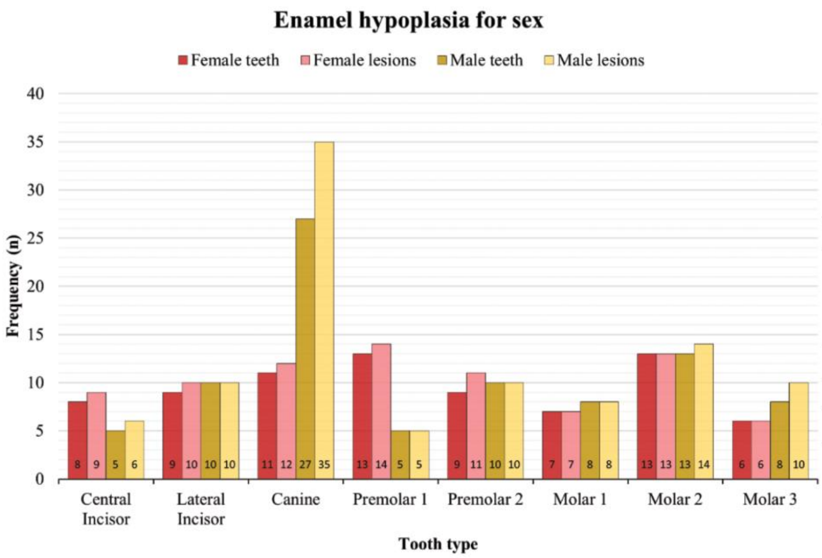
Figure 6.21: Heat map demonstrating the frequency of teeth with enamel hypoplasia on individual morphological tooth types for the entire dental arcade. Green shades indicate little to no presence, whereas red shades indicate higher prevalence.

Males had a higher frequency of EH (61%; 27/44) than females (39%; 17/44) out of sexed individuals (Figure 6.22). Male teeth had similar patterns of EH distribution, and canines had the highest frequencies, followed by second molars. In posterior teeth, female EH was observed more frequently on the first premolars, with 17% (13/76) of total female teeth and second molars, with 17% (13/76).

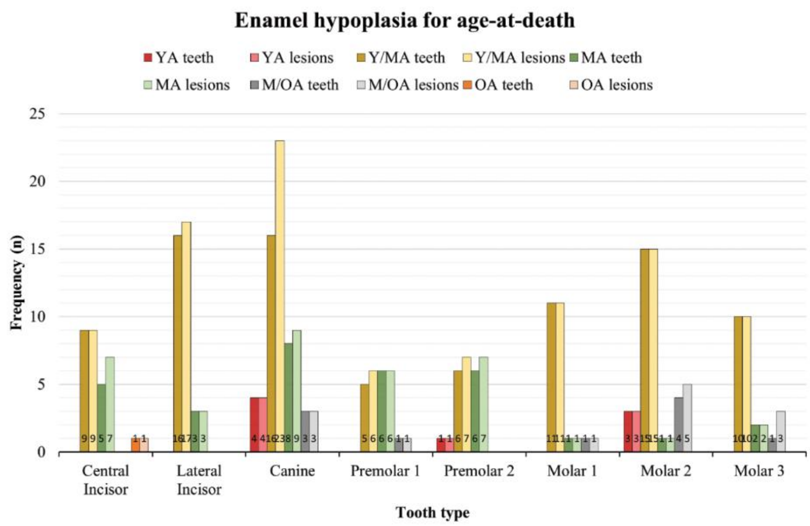
In aged individuals, EH was observed the most in young/middle adults (47%; 17/36), followed by middle adults (22%; 8/36), and middle/old adults, with (17%; 6/36) (Figure 6.22). This condition was uncommon in young and old adults. Regarding age categories with substantial occurrences of EH, a higher frequency was consistently observed on canines, followed by second molars, except for the lateral incisors for young/middle adults, which demonstrated 18% (16/88) of total hypoplastic teeth for young/middle adults.

For individuals with provenances, coastal individuals included 84% (46/55) of total individuals with EH, followed by inland individuals with 16% (9/55) (Figure 6.22). Tooth types from coastal individuals followed the same patterns mentioned above, where canine teeth demonstrated the highest frequency, with 25% (39/159) total coastal teeth with EH, followed by second molars and lateral incisors, both representing 13% (20/159) of total coastal teeth with EH. Inland individuals did not follow this pattern and demonstrated the highest frequency on the second molars, with 45% (10/22) of total inland teeth, followed by canines with 14% (3/22) of total inland teeth with EH.

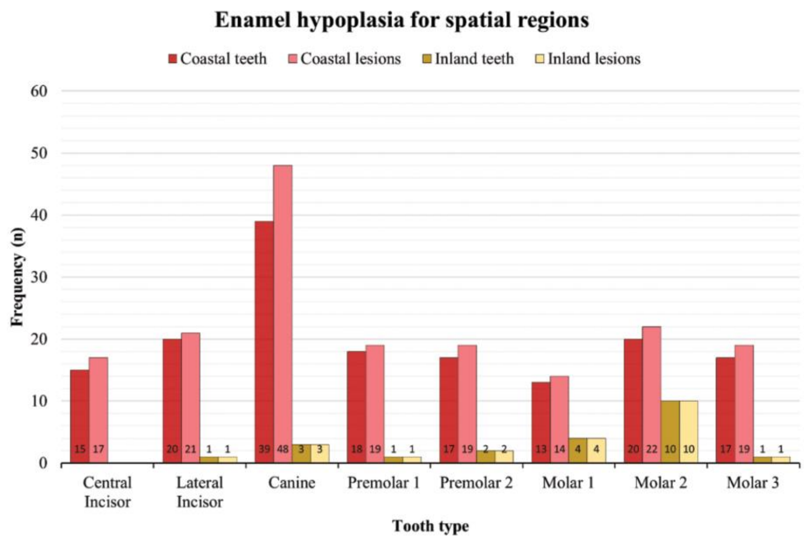
Individuals from pre-2000 BP demonstrated 55% (24/44) of dated individuals with EH, followed by post-2000 BP individuals with 45% (20/44) (Figure 6.24). Both periods demonstrated the same aforementioned general pattern in the frequency of EH per tooth type. Similarly, for Holocene divisions, this condition was observed equally between the middle and later Holocene, both representing 45% (20/44) of total individuals with EH, where the later Holocene demonstrated 9% (4/44) of total individuals with EH (Figure 6.24). Where there were substantial occurrences of EH on teeth, the middle Holocene demonstrated similar frequency patterns per tooth type. However, the later Holocene demonstrated the highest frequency in the second molars, with 26% (18/70) of total later Holocene teeth with EH, followed by the first molars, with 20% (14/70) of total later Holocene teeth with EH.



	Frequency of enamel hypoplasia		
	# of Individuals	# of Teeth	# of Lesions
Variables	***n (%)***	***n (%)***	***n (%)***
Sex			
Female	17 (39)	76 (47)	82 (46)
Male	27 (61)	86 (53)	98 (54)
Total sexed	**44 (80)**	**162 (90)**	**180 (90)**
Indeterminate	11 (20)	19 (10)	21 (10)
Total	**55**	**181**	**201**

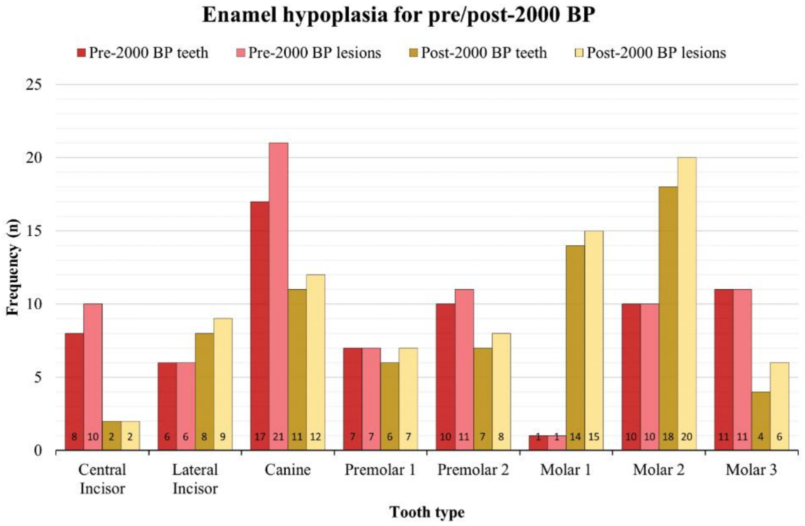


	Frequency of enamel hypoplasia		
	# of Individuals	# of Teeth	# of Lesions
Variables	***n (%)***	***n (%)***	***n (%)***
Age-at-death estimate			
Young adult	4 (11)	8 (6)	8 (5)
Young/middle adult	17 (47)	88 (63)	98 (63)
Middle adult	8 (22)	32 (23)	36 (23)
Middle/old adult	6 (17)	10 (7)	13 (8)
Old adult	1 (3)	1 (1)	1 (1)
Total aged	**36 (65)**	**139 (77)**	**156 (78)**
Indeterminate	19 (35)	42 (23)	45 (22)
Total	**55**	**181**	**201**

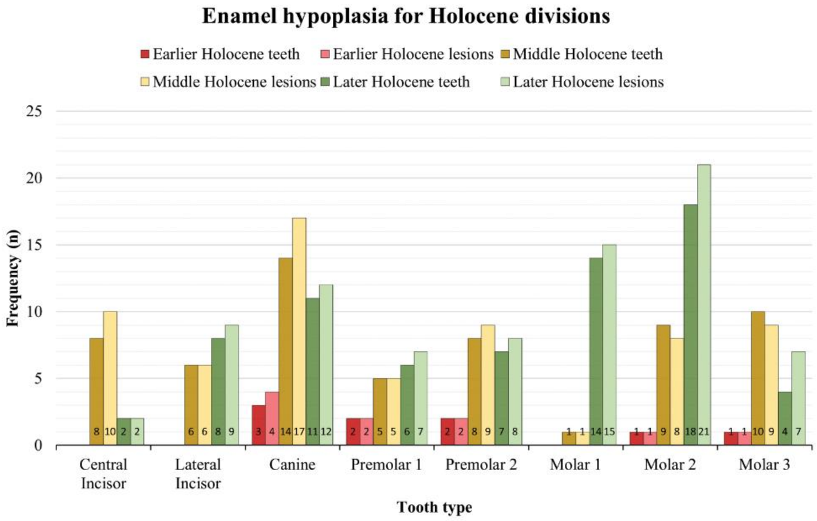


	Frequency of enamel hypoplasia		
	# of Individuals	# of Teeth	# of Lesions
Variables	***n (%)***	***n (%)***	***n (%)***
Spatial regions			
Coastal	46 (84)	159 (88)	179 (89)
Inland	9 (16)	22 (12)	22 (11)
Total with provenance	**55 (100)**	**181 (100)**	**201 (100)**
Unknown	0	0	0
Total	**55**	**181**	**201**

Figure 6.22: Frequency of teeth with hypoplasia and hypoplastic lesions on tooth types for demographic variables. From top to bottom: sex, age-at-death, spatial regions. Totals and relative frequencies calculated against totals of scored variables and indeterminate/unknown frequencies calculated against the entire affected sample.



	Frequency of enamel hypoplasia		
	# of Individuals	# of Teeth	# of Lesions
Variables	*n (%)*	*n (%)*	*n (%)*
Pre-/Post-2000 BP			
Pre-2000 BP	24 (55)	70 (50)	77 (49)
Post-2000 BP	20 (45)	70 (50)	79 (51)
Total dated	**44 (80)**	**140 (77)**	**156 (78)**
Unknown	11 (20)	41 (23)	45 (22)
Total	**55**	**181**	**201**



	Frequency of enamel hypoplasia		
	# of Individuals	# of Teeth	# of Lesions
Variables	*n (%)*	*n (%)*	*n (%)*
Holocene divisions			
Earlier Holocene	4 (9)	9 (6)	10 (6)
Middle Holocene	20 (45)	61 (44)	65 (42)
Later Holocene	20 (45)	70 (50)	81 (52)
Total dated	**44 (80)**	**140 (77)**	**156 (78)**
Unknown	11 (20)	41 (23)	45 (22)
Total	**55**	**181**	**201**

Figure 6.23: Frequency of teeth with hypoplasia and hypoplastic lesions on tooth types for demographic variables. From top to bottom: pre/post-2000 BP and Holocene divisions. Totals and relative frequencies calculated against totals of scored variables and unknown frequencies calculated against the entire affected sample.

6.6.1 Enamel hypoplasia discussion

All demographics were assessed for EH; however, hypoplastic markers do not correlate with diet and behaviours in adulthood, rather, they occur during tooth development in childhood and persist into adulthood as a representation of periods of physiological stress before adulthood (Hillson, 2008). Due to its aetiology, conducting statistical models to assess the effects of EH expression on individual tooth types against multiple factors, along with including adult age as a variable that does not play a role in EH expression, was deemed out of scope for this study. This section includes any observations using frequency statistics on EH expression and is noteworthy that potential stressors are elaborated on relative to the presence or absence of EH on each tooth type as opposed to the precise location on the crown.

EH was present on 15% (55/369) of the sample, 3% (181/6271) of present teeth, and there were 201 total defects. It was more frequent on maxillae (59%, 107/181) than on mandibles (41%, 74/181). Gibbon and Davies (2020) similarly reported LEH to occur in 11% of their sample (16/102), predominantly affecting the canines, followed by the incisors and premolars. In this thesis, canine teeth also had the highest frequency of EH (23%, 42/181), indicating metabolic stress during the weaning period for sAHGH children. This period occurred slightly later than some populations (Harrington & Pfeiffer, 2008), between two and four years of age (Konner & Worthman, 1980; Clayton, Sealy & Pfeiffer, 2006; Gibbon & Davies, 2020), rather than EH occurring from a period of episodic starvation (Patrick, 1989). This age range is plausible because canine crowns begin forming at six months and are complete by six or seven years, depending on the population (AlQahtani, Hector & Liversidge, 2010; Nelson, 2015). As a child weans from breast milk, their metabolic stress increases because they need more nutrition than the milk can provide. The child undergoing weaning then endures moderate physiological stress as they adjust their diet to gradually obtain nourishment from other sources (Clayton, Sealy & Pfeiffer, 2006; Pfeiffer, 2007). This may have weakened the immune system making the body susceptible to additional pathology (Regezi, Sciubba & Jordan, 2017). Although despite these stressors at an early age, sAHGH individuals demonstrated a good survival rate considering they lived well into adulthood despite present hypoplasia. Harrington and Pfeiffer (2008) elaborated on sAHGH later weaning ages and non-adult mortality risk, as initially mentioned by Clayton and colleagues (2006), using femoral shaft measurements on non-adult remains. The authors concluded that non-adult growth was consistent with healthy rates despite later weaning during the later Holocene, and mortality risk did not necessarily increase due to later weaning, affirming the general biological resilience of sAHGH.

Canine teeth are more susceptible to EH in most individuals (Hassett, 2014), for example, in an Iron Age Zambian population (Gibbon & Grimoud, 2014), Late Neolithic and Early Bronze Age populations (Tomczyk, Tomczyk-Gruca & Zalewska, 2012) and early Egyptian and Nubian agriculturalists (Starling & Stock, 2007). For this reason, many controlled studies have concentrated on isolating and examining canine teeth (Berbesque & Doran, 2008; Temple, 2010; Pezo-Lanfranco et al., 2020). Despite canines being commonly affected teeth, in this study, the second molar was the second-most affected tooth with EH. Second molar crown formation occurs between two and eight years of age (Nelson, 2015; Esan & Schepartz, 2018), further affirming sAHGH weaning ages and the required recovery for adequate nutrition at the end of the weaning process (Clayton, Sealy & Pfeiffer, 2006).

6.6.1.1 Enamel hypoplasia and demographics

Males demonstrated more EH (61%, 27/44) than females (39%, 17/44), but both sexes exhibited hypoplasia on teeth with crown formation times that align with expected weaning periods (Clayton, Sealy & Pfeiffer, 2006). Males demonstrated EH mainly on the canines (15%, 27/181), then second molars (17%, 13/181), and females on the second molars (17%, 13/181) and first premolars (17%, 13/181). Considering that the canine and the second molar correspond with the age of weaning, the first premolar also met this expectation as crown formation occurs between two and five and a half years of age (Nelson, 2015; Esan & Schepartz, 2018). Concerning the slight discrepancy between sexes, sAHGH ethnographic accounts have reported that sAHGH children were required to learn gender-based roles in their community from an early age (Tanaka, 1980). Assuming female roles involved foraging in precontact periods, past research suggested that females consumed foraged food during gathering expeditions (Sealy et al., 1992). If young females accompanied the older females in gathering expeditions, acquiring regular, adequate nutrition through ‘snacking’ may favour young females. Post-wean recovery may have been more difficult for male children as they may lack adequate nutritional supplementation when it was most required during and following weaning, compared to young female children. Dietary differences from labour distribution have been observed in global HGH groups, as reported by Temple (2011) on Jōmon foragers, although in caries prevalence. The author indicated significant differences in pathology for female's were relative to dietary and behavioural variation in the division of labour and resulting access to foods, namely greater access to cariogenic foods for females. Although, in another study assessing systemic stress for Jōmon HGH and Yayoi agriculturalists, Temple (2010) also noted variation in genetic capacity to buffer against external stressors, thus, females may have had a wider biological stress buffer that better resisted physiological stress, where males can be more affected by environmental adversity such as undernutrition (Stinson, 2012).

The coast has been affiliated with a greater resource availability from an abundance of marine protein relative to the productivity of the Atlantic and Indian oceans (Pfeiffer & Sealy, 2006), further reflected by large shell middens uncovered along the coastline adjacent to intertidal platforms (Pfeiffer, 2007). An assumption may be that inland individuals would reflect more stress markers as it may have been more challenging to obtain food inland than in coastal environments. These data did not meet this expectation, largely due to sample bias, as EH was more frequent for coastal individuals (84%, 46/55) than inland (16%, 9/55) individuals. Moreover, Harrington and Pfeiffer (2008) examined weaning in non-adults, including inland and coastal remains, and drew no regional conclusions.

EH prevalence was almost equal between temporal periods and Holocene divisions, besides temporal sample bias, as discussed in Chapter 4. Otherwise, the results for equal representation between the middle and later Holocene object to the expectation from the literature that there is a gap in evidence of hypoplastic defects in the later Holocene (Pfeiffer et al., 2019). These data do not correspond with the expectation of an increase in defects during the middle Holocene, to reflect increasing physiological stressors, particularly in childhood during a potentially stressful period between 4000 and 2000 BP (Pfeiffer & Sealy, 2006). These results may suggest a general biological resilience in sAHGH despite changing food processing techniques or dietary options.

Interestingly, the second molars represented the highest frequency of teeth with EH within the later Holocene, but unique to other Holocene divisions, the second-most affected tooth type were the first molars. First molars have the youngest crown formation time of the entire dental arcade, where crown formation occurs between birth to three years of age (Nelson, 2015; Esan & Schepartz, 2018). The first molar suggests that individuals within the later Holocene underwent physiological stress around infancy, precursing weaning stressors considering sAHGH weaned their children quite late (Harrington & Pfeiffer, 2008). Pfeiffer and colleagues (2014) examined mortality risk associated with childbirth for post-2000 BP sAHGH and found that the risk of death doubled for young women between 18 and 24 years of age, likely related to parturition. Accordingly, the results from this thesis demonstrated an increase in physiological stress amongst sAHGH infants during the later Holocene as measured by EH on the first molar. This was potentially associated with the gradual development of nutritional infertility following the middle Holocene (Konner & Worthman, 1980) before weaning commenced, and there was a notable rate of survival despite potential stressors considering the individuals in this sample were adults (Harrington & Pfeiffer, 2008). Considering these observations, an increased mortality rate in young female adults (Pfeiffer et al., 2014) and the transition into new lifestyles (Wells, DeSilva & Stock, 2012) may have contributed to EH occurring slightly more frequently during infancy in post-2000 BP. Thus, these results may have been due to changing food processing techniques or dietary options which increased food security despite the fluctuations in population size from the previous period.

6.6.1.2 Amelogenesis imperfecta

One individual had an extremely high frequency of EH lesions on all surfaces of the entire dental arcade (Figures 6.24 and 6.25), and the defects were inconsistent and of multiple types (linear, pitting). A differential diagnosis was established as amelogenesis imperfecta (AI), a hereditary condition (Aldred, Savarirayan & Crawford, 2003; Crawford, Aldred & Bloch-Zupan, 2007; Gadhia et al., 2012; Seow, 2014). Although radiographic examination would provide further insights into the type of AI (Gadhia et al., 2012), macroscopically, the individual exhibited characteristics of either hypoplastic or hypomaturation AI, which present as pitting and linear grooving, as well as opaque and mottled enamel that is reduced in thickness and can be prone to fracturing (Gadhia et al., 2012; Seow, 2014). AI occurs through mutations in one of five types of genes; ENAM, AMELX, KLK4 and MMP20, AMELOTIN or FAM83H, where the resultant type of AI depends on the pattern of inheritance and the mutation itself (Gadhia et al., 2012). AI conditions are rare and are associated with high morbidity, particularly dental comorbidities (Ayers et al., 2004; Gadhia et al., 2012). All teeth were present except for three teeth lost postmortem, and there were signs of other oral health conditions, including three carious lesions on the mandibular molars (3.6, 3.7, 4.6) and six visible infectious lesions, all located around the maxillary anterior teeth and premolars.

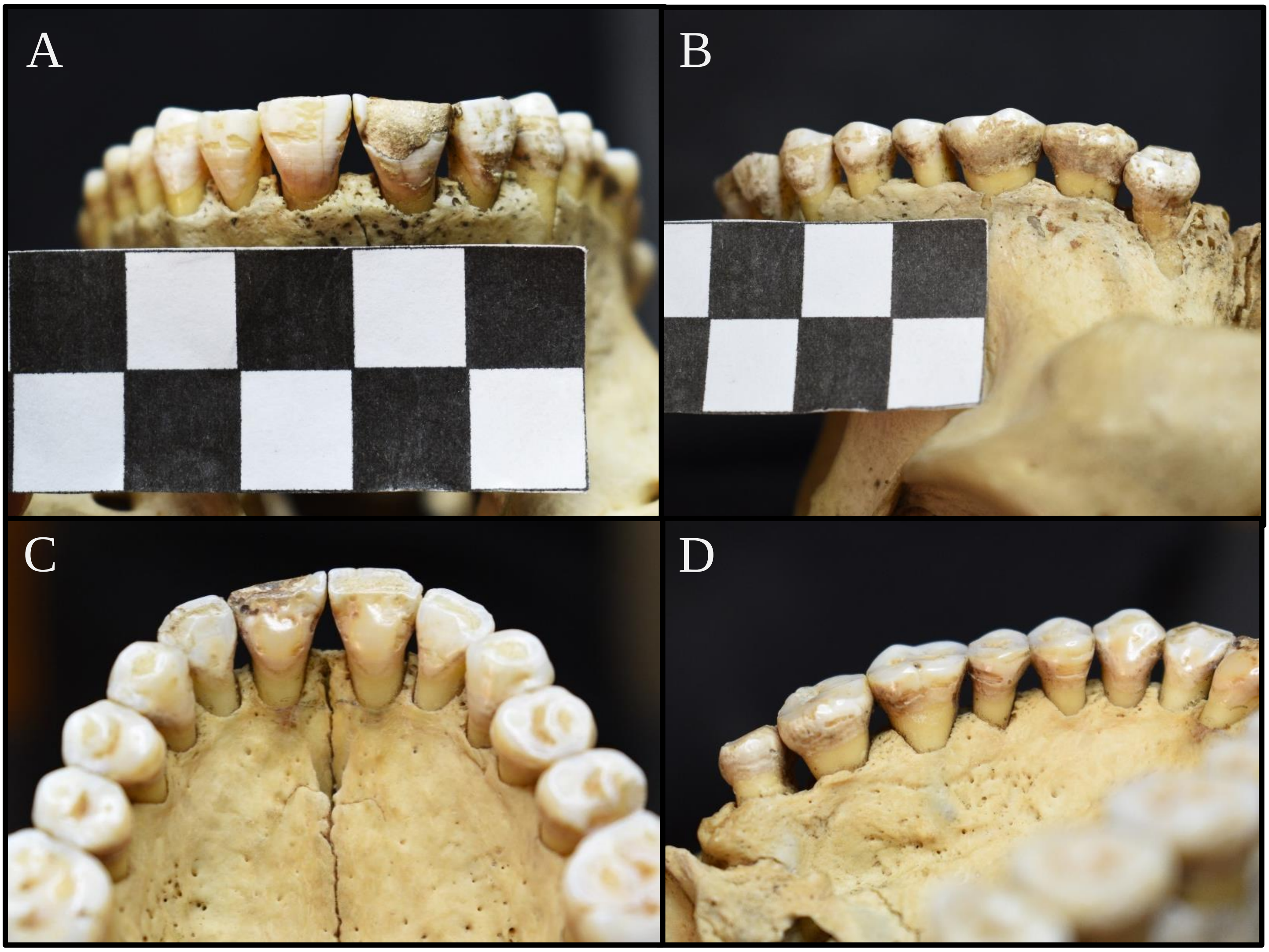


Figure 6.24: Amelogenesis imperfecta on individual (UCT 107) as demonstrated by numerous, inconsistent types of hypoplasia (linear and pitted). (A) Maxillary teeth, facial view; (B) Upper left quadrant, facial view; (C) Maxillary teeth, lingual view; (D) Upper left quadrant, palatal view.

Figure 6.25: Amelogenesis imperfecta on the dental arcade in occlusion for UCT 107, demonstrating the extent and variety of hypoplastic defects on all present teeth. The upper photo demonstrates the facial view from the lefthand side, and the bottom photo demonstrates the facial view from the righthand side.

The individual had an age estimate of middle/old adult which suggested that they survived well into adulthood. They dated to the middle Holocene, notable in the literature for being a biologically stressful period of rapid population growth, reflected by reduced sAHGH body size (Sealy & Pfeiffer, 2000; Pfeiffer & Sealy, 2006; Kurki et al., 2010). This individual's resilience may have been because they inhabited the coast, with sufficient access to a steady supply of marine resources (Sealy & van der Merwe, 1988; Sealy et al., 1992; Stock & Pfeiffer, 2004; Sealy, 2006). This individual had a provenance of modern Knysna, where an isotopic study conducted by Sealy (2010) further reported that individuals exhibiting the largest marine food intake during the middle Holocene were from the Robberg Peninsula and Plettenberg Bay.

This region was critical to the concluding diagnosis of AI as opposed to clinical fluorosis (Wondwossen et al., 2004; Marín et al., 2016) as the geographic area has been notable in archaeological and contemporary literature for low water fluoride reflected by accounts of localised high caries frequency (Ockerse, 1943; Grobler & Dreyer, 1988; Patrick, 1989; Sealy et al., 1992) as has already been discussed in detail within section 6.4.2.2. With these environmental factors in mind, endemic fluorosis would be unusual in a region with notably low fluoride contents below 2ppm. Moreover, no other individuals from a similar spatial region presented with a similar case of extreme hypoplastic dental symptoms, supporting the hereditary nature of the condition as opposed to occurring through an endemic condition during the middle Holocene.

Botha and Steyn (2016) reported similar observations on the enamel of three molars and premolars of a non-adult (11 to 13 years) sAHGH individual dating to the late 19th or early 20th century. As in this thesis, the authors also noted the possibility of AI, amongst additional differential diagnoses of congenital treponematosis (i.e., congenital syphilis) and cuspal enamel hypoplasia. Where the individual within this thesis does not exhibit characteristics supporting congenital treponematosis in the form of irregularly cusped, dome-shaped molar surfaces (Moon molars) and 'narrowly' shaped incisors (Hutchinson incisors) (Neville et al., 2019) the enamel of their dentition appears only to reflect excessive, irregular hypoplastic defects, which also suggests a condition greater than general cuspal hypoplasia. Therefore, where a case of AI has been reported for sAHGH (Botha & Steyn, 2016), this is the first known report of the possible presence of AI occurring as early as the middle Holocene in archaeological sAHGH remains.

6.7 Dental trauma

Pathological dental trauma in the form of chipping, was scored on a reduced sample size (n = 266 individuals; n = 4827 total teeth) due to methodological issues in initial data collection (Figure 6.1). Overall, 21% (55/266) of total individuals were observed with pathological dental trauma, 2% (94/4827) of teeth with a chip, and 106 total observed chips on all observed teeth. The frequency of chipped teeth between maxillae and mandibles was closely distributed between jaw and tooth types. Second molars were most frequently affected by chipping, representing 30% (28/94) of all chipped teeth, closely followed by second premolars (24%; 23/94). Anterior teeth were the fewest affected by chipping. The degree of chipping most frequently observed in this sample was superficial enamel flake loss (grade 1), representing

46% (49/106) of total microchips, followed by 38% (40/106) of square lesions with enamel involved up to dentine (grade 2), and 16% (17/106) of larger irregular fractures involving enamel and dentine (grade 3). The three grades of dental trauma observed in this sample are presented in Figure 6.26. The mesiobuccal cusp was the most frequently affected location on the teeth, demonstrated by 23% (24/106) of total chips, whereas the entire lingual surface was the least affected location, with 4% (4/206) of chips observed on this surface.

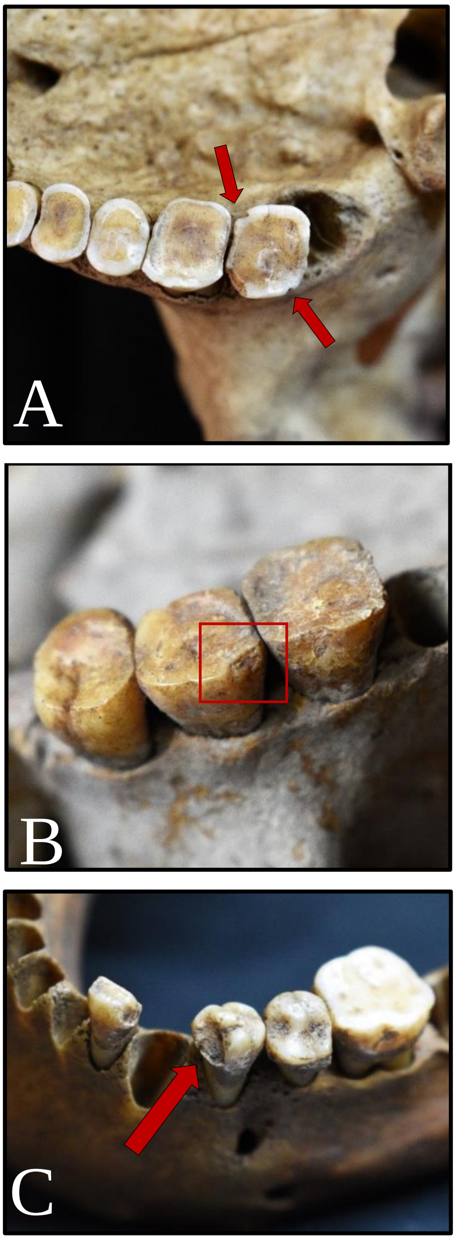


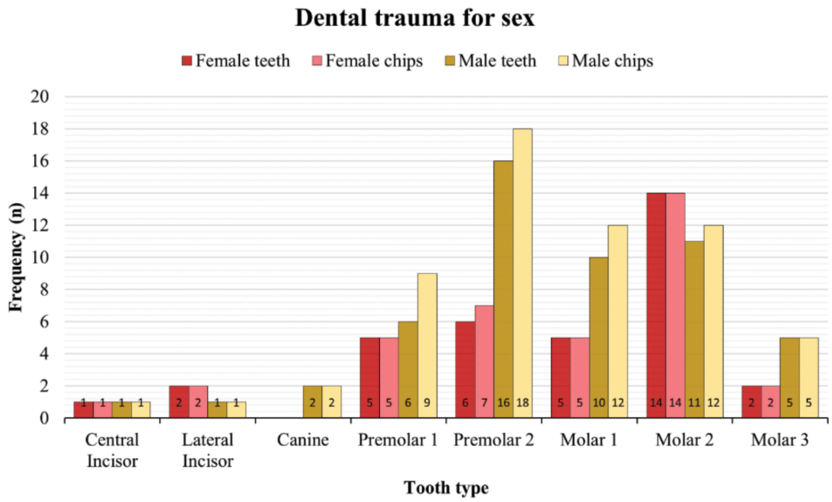
Figure 6.26: Examples of three grades of dental trauma, (A) Grade 1: Superficial enamel flake loss (UCT 618), (B) Square irregular lesion with enamel involved (up to dentine) (UCT 230), (C) Large irregular fracture involving enamel and dentine (UCT 579).

Between sexed individuals, males had higher frequencies of chipped teeth, 52% (25/48), compared to female individuals, with 48% (23/48) (Figure 6.27). Chip distribution on all tooth types was similar, except males had slightly more chips observed in the second premolars and first molars than females.

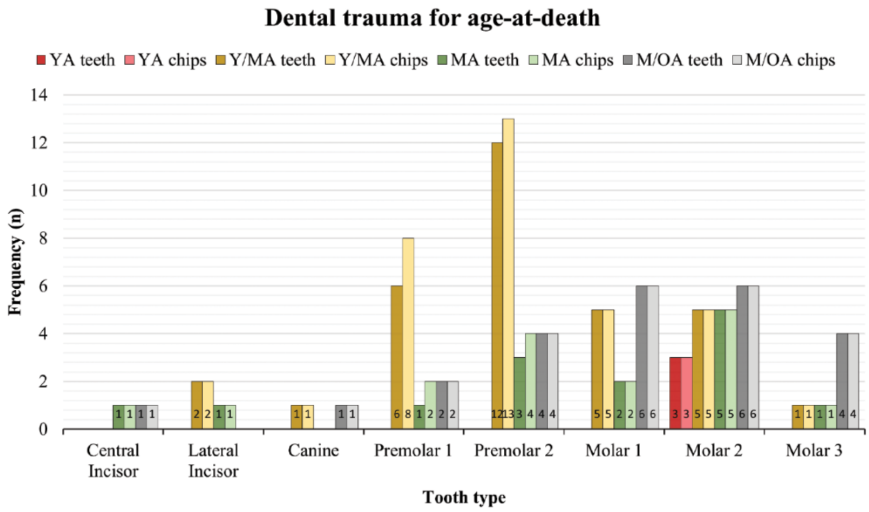
Amongst aged individuals, young/middle adult individuals demonstrated the highest frequency of chipped teeth (44%; 18/41), and there were no old adults with chipped teeth and one young adult with chipped teeth (Figure 6.27). Between age groups that showed evidence of chipping, the second molars and second premolars tended to be the most frequently chipped tooth type.

Of provenanced individuals, coastal individuals demonstrated the most chipping, amounting to 91% (49/54) of the observed sample, whereas inland individuals represented 9% (5/54) of individuals with chipped teeth (Figure 6.27). Despite this notable discrepancy, chipping was distributed relatively equally between tooth types of both regions, with second molars and second premolars being the most affected.

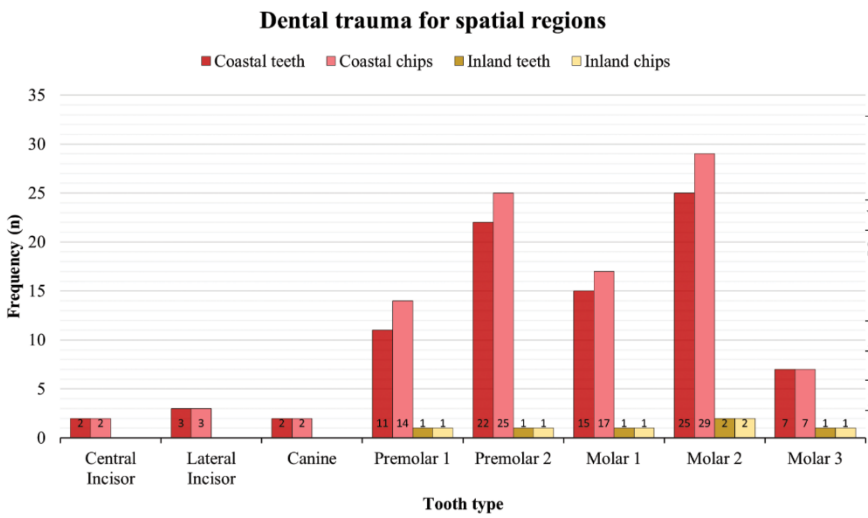
For dated individuals, 65% (31/48) of individuals with a chipped tooth were from pre-2000 BP, whereas 35% (17/48) were from post-2000 BP (Figure 6.28). Chipping was distributed similarly across tooth types between both temporal periods; however, there were slightly more instances of second premolar chipping in pre-2000 BP than post-2000 BP. Within Holocene divisions, the middle Holocene had the most individuals with a chipped tooth, totalling 52% (25/48) of affected individuals, followed by the later Holocene (35%; 17/48), and the earlier Holocene (13%; 6/48) (Figure 6.28). Between Holocene divisions, the earlier Holocene had few occurrences of chipping across tooth types. Interestingly, second premolars from the middle Holocene exhibited were most frequently affected by chipping ahead of the second molars, while the later Holocene had the second molars most frequently affected ahead of the second premolars.



	Frequency of dental trauma		
	# of Individuals	# of Teeth	# of Chips
Variables	***n (%)***	***n (%)***	***n (%)***
Sex			
Female	23 (48)	35 (40)	36 (38)
Male	25 (52)	52 (60)	60 (63)
Total sexed	**48 (87)**	**87 (93)**	**96 (91)**
Indeterminate	7 (13)	7 (7)	10 (9)
Total	**55**	**94**	**106**

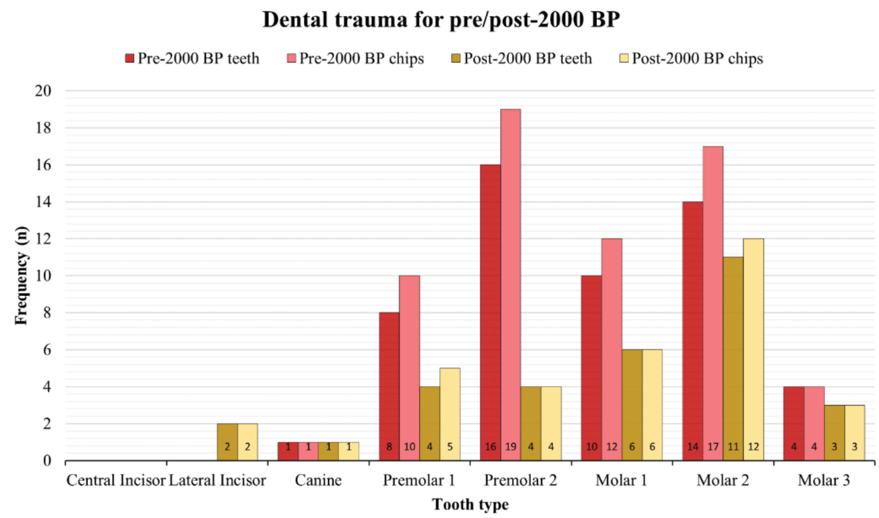


	Frequency of dental trauma		
	# of Individuals	# of Teeth	# of Chips
Variables	***n (%)***	***n (%)***	***n (%)***
Age-at-death estimate			
Young adult	1 (2)	3 (4)	3 (4)
Young/middle adult	18 (44)	32 (44)	35 (45)
Middle adult	10 (24)	14 (19)	16 (21)
Middle/old adult	12 (29)	24 (33)	24 (31)
Old adult	0	0	0
Total aged	**41 (75)**	**73 (78)**	**78 (74)**
Indeterminate	14 (25)	21 (22)	28 (26)
Total	**55**	**94**	**106**

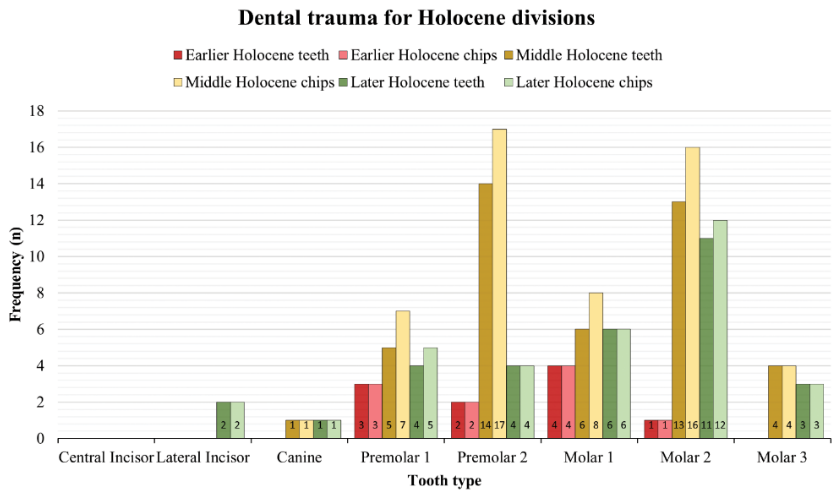


	Frequency of dental trauma		
	# of Individuals	# of Teeth	# of Chips
Variables	***n (%)***	***n (%)***	***n (%)***
Spatial regions			
Coastal	49 (91)	87 (94)	99 (94)
Inland	5 (9)	6 (6)	6 (6)
Total with provenance	**54 (98)**	**93 (99)**	**105 (99)**
Unknown	1 (2)	1 (1)	1 (1)
Total	**55**	**94**	**106**

Figure 6.27: Frequency of teeth with pathological dental trauma and number of chips per tooth type for demographic variables. From top to bottom: sex, age-at-death and spatial regions. Totals and relative frequencies calculated against totals of scored variables, and indeterminate/unknown frequencies calculated against the entire affected sample.



	Frequency of dental trauma		
	# of Individuals	# of Teeth	# of Chips
Variables	***n (%)***	***n (%)***	***n (%)***
Pre-/Post-2000 BP			
Pre-2000 BP	31 (65)	53 (63)	63 (66)
Post-2000 BP	17 (35)	31 (37)	33 (34)
Total dated	**48 (87)**	**84 (89)**	**96 (91)**
Unknown	7 (13)	10 (11)	10 (9)
Total	**55**	**94**	**106**



	Frequency of dental trauma		
	# of Individuals	# of Teeth	# of Chips
Variables	***n (%)***	***n (%)***	***n (%)***
Holocene divisions			
Earlier Holocene	6 (13)	10 (12)	10 (10)
Middle Holocene	25 (52)	43 (51)	53 (55)
Later Holocene	17 (35)	31 (37)	33 (34)
Total dated	**48 (84)**	**84 (89)**	**96 (91)**
Unknown	7 (13)	10 (11)	10 (9)
Total	**55**	**94**	**106**

Figure 6.28: Frequency of teeth with pathological dental trauma and number of chips per tooth type for demographic variables. From top to bottom: pre/post-2000 BP and Holocene divisions. Totals and relative frequencies calculated against totals of scored variables, and unknown frequencies calculated against the entire affected sample.

6.7.1 Dental trauma discussion

Dental trauma results demonstrated that 21% (55/266) of individuals and 2% (94/4827) of teeth were affected, with 106 total chips observed. The posterior teeth of HGH populations tend to exhibit higher rates of chipping, whereas agricultural groups tend to fracture the anterior teeth (Stojanowski et al., 2016). This study reflected this expectation as the posterior teeth were mainly affected by chipping, particularly second molars 30% (28/94) and second premolars 24% (23/94), and all anterior teeth were the fewest affected. The less frequent occurrences of anterior chipping may have been due to heavy enamel wearing that was prevalent on the anterior teeth of this sample, in essence, wearing away any chips or fractures on the crown that may have previously been present. As Van Reenen (1992) discussed, most premolar and molar chipping would be induced by breaking nuts and seeds and may increase in size from environmental abrasion (e.g., sand), further contributing to dental wear. Mesial and distal fracturing of posterior teeth may have also accentuated by the vestibular insertion of an object, such as a pick to clean teeth or simply to hold a narrow tool, as maxillary and mandibular microfracturing were closely distributed. Bonfiglioli and colleagues (2004) reported that corresponding notches between the same maxillary and mandibular tooth type might suggest non-masticatory behaviours in addition to accidental trauma. This remains a possibility as dental pick use was reported as a possibility in Chapter 5.

Micro fracturing was the type of trauma most frequently observed, which Milner and Larsen (1991) define as the loss of minute enamel chips up to and including larger blocks of enamel. The mesiobuccal cusp of the posterior teeth was the most frequently affected location in this study, which appears to correspond with ethnographic and archaeological expectations of sAHGH using the posterior teeth to break nuts and seeds (Lee, 1979; Van Reenen, 1992). Considering the anterior teeth wore down to the pulp ahead of the posterior teeth, using the front teeth to open sharp and hard items may have been painful once the enamel had worn away, as the enamel can withstand more stress than dentine (Scott & Winn, 2011). The fewest occurrences for all grades of trauma were grade 3 fractures in this study (16%; 17/106). The lack of larger fractures may have been due to sAHGH reportedly having an overall more negligible risk of dental trauma, sAHGH teeth were small (Black, 2014) with no over-exposure and competent lip coverage, along with the lack of dental arch malocclusion in the form of overbites, both from well-positioned teeth and rapid dental wear that remodels bite alignment to an ‘edge-to-edge’ bite (Van Reenen, 1964), which were characteristics that may have reduced risk of dental trauma (Bastone et al., 2000).

The few occurrences of anomalous malalignments or malocclusion (i.e., crowding, supernumerary, ectopic, and impacted teeth) (n = 12), illustrated in Section 6.8, may have contributed to reduced trauma incidence, where isolated misaligned teeth tend to chip as they lack the supportive structural integrity of aligned teeth (Craddock & Youngson, 2004). Bastone and colleagues (2000) reviewed dental trauma literature and reported that many studies had indicated accidents to falls being the most common factor in the aetiology of dental chipping, where other recurrent causes were sport and violence. Due to micro-fracturing being the most prevalent, trauma in this sample was more likely associated with non-masticatory tasks than violence (Belcastro et al., 2018). Nonetheless, interpersonal violence, as represented by the prevalence of cranial injuries, has been a contested subject in sAHGH and remains a possibility (Morris, 2012, 2020). Although several earlier studies have reported that violence was transient between periods for people subjected to occasional population distress; therefore, there was an overall, general rarity of consistent violent outbursts (Pfeiffer & Harrington, 2011; Pfeiffer, 2016; Pfeiffer et al., 2019).

6.7.1.1 Dental trauma and demographics

The results in this thesis showed dental trauma occurred slightly more in males (52%; 25/48) than females (48%; 23/48), which is reportedly a common observation between sexes between populations (Bastone, Freer & McNamara, 2000). Both males and females demonstrated frequent chipping on the second molars and premolars, which, as has been previously discussed, chipping of posterior teeth may be due to the processing and chewing of hard and abrasive food, shells, nuts, seeds, fruit stones, and bones (Bonfiglioli et al., 2004), of which both sexes would have used the teeth for these reasons (Van Reenen, 1992).

Enamel permeability is weaker and more brittle in older individuals, which is exacerbated by increasing loading pressure that may sooner crack the enamel, particularly as it remains a thin rim around the softer dentine in advanced wear stages (Solheim, 2013). In this study, the young adults aligned with this expectation where only a singular individual exhibited dental trauma. The young/middle-aged adults exhibited the most frequent occurrences of dental trauma (44%; 18/41), with a general decrease in trauma following each subsequent age category until old adults exhibited an incidence rate of zero for dental trauma. This may be due to skewed sample representation; it also may be due to advanced dental wear, where the enamel was already wearing away in old adults, along with any trauma that would have been visible on the surface. As with all other demographic variables, anterior teeth demonstrated the fewest microfractures in younger adults. If anterior trauma occurred more frequently, it would have been noted in younger individuals as the crowns would be more prevalent, as Belcastro and colleagues (2018) reported on a moderate incidence rate for intact anterior crowns in young Neanderthal individuals ranging between five to 20 years of age. This suggests that anterior trauma was minimal overall in sAHGH teeth and premolar and molar chipping was likely related to consuming hard or brittle foods, or parafunctional habits from the use of picks or tools between the teeth.

Sampling bias was acknowledged for spatial classifications, and considering there were low incidence rates for trauma on inland individuals (9%; 5/54), comparisons are difficult to discuss. Temporal observations remained notable because trauma was more prevalent in pre-2000 BP (65%; 31/48) and, when divided further, explicitly in the middle Holocene (52%; 25/48). Although dental trauma observed in this sample does not necessarily reflect interpersonal violence, it is worth noting that where sAHGH violence has been discussed, several studies reported a possible increase in violence between 3000 and 2000 BP due to stress from population increase and resource management (Pfeiffer & Sealy, 2006; Pfeiffer & Harrington, 2011; Pfeiffer, 2016; Gibbon & Davies, 2020). An alternative suggestion to this increase in middle Holocene trauma, especially in the posterior teeth, may also be due to some sites' increased reliance on terrestrial foods (Sealy & Pfeiffer, 2000; Stock & Pfeiffer, 2004; Ginter, 2011). Terrestrial foods would have been tougher on the teeth than marine resources because of their brittle and fibrous nature and may have justified increased behaviour of cracking seeds and nuts or biting down on bone, resulting in more loading pressure on the enamel, demonstrated by cracks and fractures. Moreover, with the appearance of a single fracture, the compromised tooth structure incites the surface to additional damage (Scott & Winn, 2011). Along with other oral health results from this study, oral health appeared to improve post-2000 BP, which may be due to the introduction of a herding lifeway, with changing tool industry complexes and, potentially, tools that apply less pressure on the teeth as a third hand such as the grinding of foods, or stewing (Deacon et al., 1978; Sadr, 2004, 2008a,b; Ginter, 2011).

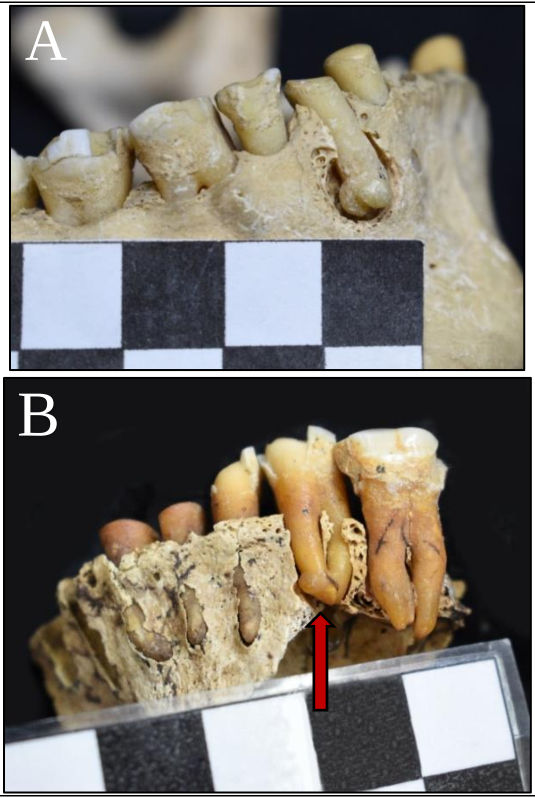
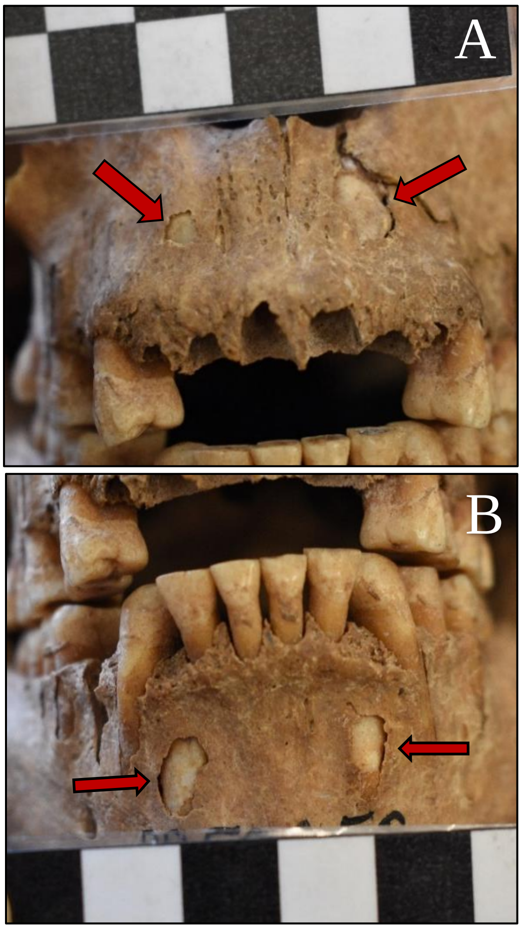
6.8 Other conditions

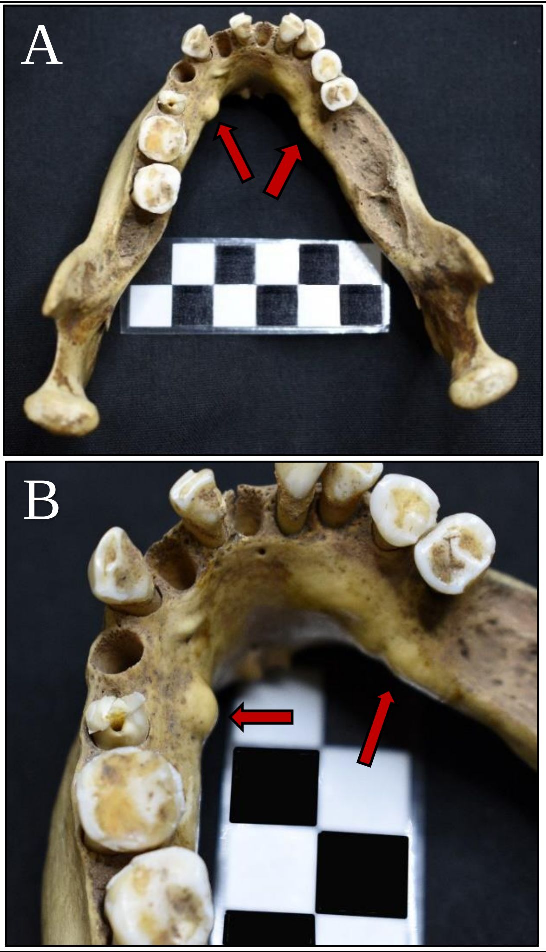
Additional oral and dental health conditions represented low frequencies and were not the primary objectives of this thesis thus were observed only when encountered. Other oral health conditions were observed in 5% (18/369) of total individuals and included conditions as listed below in Table 6.9. These conditions have already been, or will still be discussed in the subsequent chapter, in conjunction with other reported aspects in this thesis. Considering most of these conditions are considered hereditary (Gadhia et al., 2012), eruption complications (insufficient space, delayed eruption times) (Mockers, Aubry & Mafart, 2004), or multifactorial but with inconclusive aetiologies (Zhou et al., 2012; Nelson, 2015), they are out of the scope of this study as standalone conditions, and any relevant conditions—if they may affect observed oral pathologies or dental wear—are discussed in the subsequent chapter.

Table 6.9: Select photographic examples of anomalous oral health conditions from individuals as assessed in this study. Left-hand column elaborates on the type of condition, the total number of individuals on which the condition was observed, and a brief description where necessary.

Oral health condition	Photographic examples
Amelogenesis imperfecta (*n* = 1). The entire dental arcade in occlusion demonstrates the numerous hypoplastic defects on UCT 107. Figure A exhibits the right facial view; Figure B exhibits the left facial view.	 
Malocclusion and dental crowding (*n* = 9). Figure A exhibits dental crowding of the right mandibular premolars on UCT 44. In UCT 652, Figures B and C (continued on next page) exhibit dental crowding of the maxillary and mandibular incisors, respectively. Figure D (continued on next page) exhibit the resultant malalignment of the teeth in occlusion.	 

	 
Supernumerary teeth (*n* = 1). An example of a supernumerary premolar on the left maxilla of UCT 683.	

Hypercementosis (*n* = 4). Figure A exhibits hypercementosis of the right mandibular first premolar (4.4), visible through an abscess on UCT 36. Figure B exhibits hypercementosis on a root of the right maxillary first molar (1.6) on UCT 565.	
Ectopic canines/impacted teeth (*n* = 2). Figures A and B exhibit impacted teeth in the form of ectopic canines of all four canine teeth, visible through taphonomic damage, on SAM-AP 5035b.	

Mandibular tori/lingua exostosis (*n* = 1). Figures A and B exhibit mandibular tori on the mandible of UCT 43.	
Total: 18 instances of other oral health conditions	

<u>Chapter summary</u>

The results for oral pathology, including reliability assessments, distribution, and statistical assessments, were structured by pathological condition, and individually elaborated upon. Prior bioarchaeological research on sAHGH populations has demonstrated good overall oral health, demonstrated by low incidence rates for pathological conditions, with some variation regarding sexual dimorphism and spatial and temporal divisions. This chapter presented some consistencies with the literature while highlighting variations that elucidated on patterns observable in a holistic assessment. In addition, other oral conditions were presented in tandem with photographic examples, where the oldest case of AI in an sAHGH adult was reported. The collective interplay of these oral pathologies and dental wear, further compared to local and global literature, is discussed in Chapter 7.

CHAPTER 7: GENERAL DISCUSSION

I initiated this research due to the necessity for a systematic assessment of dental wear quantity, direction, and oral pathology on precontact sAHGH dentition, integrating biology with environment using a biocultural approach whilst examining these assessments against demographic variables, diet, and behaviour which considers the osteological paradox. This thesis met these aims whilst including comparisons against various demographic factors such as sex, age, spatial, and temporal divisions (pre/post-2000 BP and Holocene divisions).

This chapter amalgamates key findings from previously presented results and independent discussions against the broader aims and research questions. Where Chapters 4 to 6 have already reported and individually discussed each assessed variable, Section 7.1 assesses all oral conditions and their multifactorial impacts to provide a complete understanding of the interplay of combined oral conditions for each demographic variable of sex, age, spatial, and temporal factors. This chapter concludes with Section 7.2, which includes the implications of the previously discussed main findings on the broader understanding of sAHGH life history.

7.1 The interplay of oral conditions against demography

Oral conditions are inter-related, where the presence of one condition predisposes the tooth to the development of another, not excluding population-specific examples such as malalignment from large teeth or a small jaw making teeth further susceptible to dental trauma, caries, impaction, and infection, and eventually, periodontal disease and tooth loss (Calcagno & Gibson, 1991; Craddock & Youngson, 2004). sAHGH teeth are microdont, and although the odds of dental crowding and malocclusion reduce in microdont populations (Black, 2014)—an aspect confirmed by few cases of malalignment reported in this study (n = 12)—small teeth may remain a health liability as they may wear to the pulp faster, rendering them vulnerable to additional pathological consequences (Van Reenen, 1964; Smith, 1984). Therefore, due to the heavy wear environment, sAHGH tooth size may not just reflect dietary needs. Where tooth size selection tends to be determined by evolutionary adaptation to masticatory use (Benazzi et al., 2013), tooth size for sAHGH may have reflected a compromise between a tougher diet and certain tool use strategies resulting in reduced masticatory stress (Calcagno & Gibson, 1991). Where the rate of wear in sAHGH has been calculated by Van Reenen (1992), the results demonstrated considerable variation between demographic categories, although the sample was mixed by including living contact-period HGH and precontact skeletonised remains. Thus, covering a large expanse of time and a variety of subsistence strategies. Otherwise, sAHGH wear has been determined as rapid in the context of heavier wear early in the lifecycle (Morris, 1992a), but questions on the microdont nature of sAHGH teeth against dental wear should be assessed quantitatively in the future.

In contrast to contemporary dentition and diets, the teeth and muscles gradually adjust themselves without discomfort in rapid wearing dentition (Dahl, Krogstad & Karlsen, 1975), and as wear progresses, the continual eruption of teeth compensates for the wear (Kaidonis et al., 2012). This cascading adaptive process is a result of changing occlusal surfaces, which is faster in sAHGH teeth from a diet reliant on plant foods that are tough and fibrous in consistency (Smith, 1984; El-Zaatari, 2010). Eventually, as the findings demonstrated, the teeth will wear in a horizontal or oblique direction into non-functional forms that may expose the pulp chamber, further predisposing a tooth to pathological risk (Costa, 1980; Kaidonis et al., 2012).

Preservation is a challenge for reliable observations in bioarchaeological studies (Grauer, 1995), and a researcher must pay heed to the conceptual inferences of the osteological paradox (Wood et al., 1992) when evaluating findings the results on the remaining material may not be representative of an entire sAHGH population. Reliable observations are further complicated with the assessment of conditions such as AMTL, as incidence rates of conditions that manifest themselves on the physical tooth (e.g., caries, EH, trauma, wear) cannot be inferred when a tooth is absent (Hillson, 2008). Caries and advanced dental wear are significant causes of periodontal disease, which can result in tooth loss (Temple, 2016). Due to meaningful results for caries, infectious lesions, and heavy dental wear on the molars, chiefly the first molar and, in some cases, the anterior teeth, these may act as evidence of what certain teeth were likely predisposed to, contributing to their loss. However, the opposite conclusion may also be drawn; fewer teeth lost antemortem suggests minimal dental wear and lower susceptibility to caries (Molnar & Molnar, 1985). Caution must be exercised when examining archaeological dentition, and the assessed conditions were largely multifactorial and likely affected each other, albeit to a degree that cannot always be precisely confirmed. These aspects are considered further against assessed demographic variables in the subsequent sections.

7.1.1 Impact of sex on dental conditions

The sample for sex was reasonably balanced, and there were few appreciable effects for sexual dimorphism, although certain observations remained notable and required further consideration. Males had more teeth present overall than females, although females had higher incidence rates for AMTL. Sex distribution across ages clustered around young/middle, middle, and middle/old age categories and spatiotemporally, sexed individuals were closely distributed coastally and predominated the middle Holocene, followed by the later Holocene. Almost all inland males dated to the later Holocene (n = 22), compared to six females. However, this bias was likely due to the broader issues of archaeological recovery as data from inland regions has been limited due to excavation efforts localised along the coast (Sealy, 2010) and sporadic inland occupation, in addition to fewer recovered skeletal remains prior to the later Holocene (Stynder, 2006).

Regarding caries and infectious lesions, males had higher incidence rates. This may have been due to sampling bias as males had slightly more teeth present in young/middle, middle, and middle/old adult categories. Comparatively, females had fewer teeth and more AMTL occurrences, and this high incidence rate of female AMTL may suggest that female caries and infections were underrepresented. This considers the broader issue in bioarchaeological oral pathology assessments, where it is impossible to discern the exact number of pathological conditions that manifest on a physical tooth if it is already lost (Hillson, 2008). Additionally, caries and infectious lesion visibility may hinder from poor preservation or absence of the alveolar bone. Males also exhibited a slightly higher mean wear index of 2.3, compared to 2.2 for females. These differences in means were nearly identical, and both suggest partial dentine exposure as the average wear stage. Moreover, overall wear indices for male pulpal exposure were not significantly greater, which would be an additional factor to consider for increased male dental decay, as there tend to be positive correlations between increased wear and pathology risk (Kaidonis et al., 2012). These observations suggested dental wear was an unlikely connection between increased caries incidence rates and infections in males *versus* females.

Considering sAHGH groups likely practised resource-sharing (Boonzaier et al., 1996), a possibility that the slight increase in male caries and infections may have been due to a greater caloric intake based on past ethnographic observations. In an ethnographic study on contact period Kalahari San hunter-gatherers, Lee (1979) reported that men consumed more calories, estimated at 2250 kcal, than women at 1750 kcal per day. The author suggested that the caloric increase for men compensated for the strenuous energy output from hunting expeditions which were a male-dominated activity. Considering the sAHGH diet for both sexes included a significantly higher proportion of plant foods to meat, such as roots, melons, gums, bulbs, and fruits in both the coastal and inland environment (Lee, 1979; El-Zaatari, 2010; De Vynck, Van Wyk & Cowling, 2016), this may imply greater carbohydrate consumption affecting the teeth in the form of calculus development and eventual dental decay (Lieverse, 1999; Temple, 2016). Globally, Apicella and colleagues (2017) reported that for contemporary Hadza, Tanzanian HGH, there were variances in caloric returns between sexes with increasing age as the younger individuals began to take on social roles of either hunting or foraging. The authors also mentioned that the men consumed more calories despite similar diets to the women due to the increased likelihood of the men targeting riskier foods, thus, increasing returns. Where this is not necessarily possible to observe in these dental results, nor is this behaviour mentioned in sAHGH ethnographic records, it demonstrates the complexity behind HGH social dynamics that may otherwise have affected dietary habits.

An alternative explanation for increased male dental decay and infection rates in this sample may have been physiological, potentially associated with males exhibiting increased rates of EH as reported in Section 6.6. This considers reports of caries rates potentially being higher in later life for individuals with poor childhood nutrition (Infante & Gillespie, 1977; Alvarez et al., 1990; Alvarez, 1995), along with bacterial demineralisation targeting regions of weakened enamel from hypoplastic defects (Hillson, 2001).

Males also demonstrated higher occurrences of dental trauma, which past literature typically associates with dental modification (Milner & Larsen, 1991), interpersonal violence (Lukacs, 2007), pathological predisposition (Hillson, 1986; Alhammad, 2011), or accidental injury (Bastone, Freer & McNamara, 2000). Most examples of trauma in this sample included microchipping; therefore, cultural practice in the form of dental modification was unlikely and is considered absent in this sample. Regarding dental trauma as related to violence, sAHGH researchers have discussed violence-based trauma, and where sAHGH have exhibited evidence of inter-personal violence (Morris, 2012, 2020), dental trauma from violent encounters typically manifests on anterior teeth (Bastone, Freer & McNamara, 2000), and the results from this thesis had the fewest occurrences of trauma on anterior teeth. Therefore, trauma on sAHGH dentition due to violence may be unlikely. Consequently, an explanation for increased trauma in males may have been related to weakened enamel from hypoplastic defects, as the EH results suggested to be more frequent for male individuals. Alternatively, increase male trauma may have simply related to accidental injury. Hillson (2001) stated that localised areas of weakened enamel might fracture more easily and preferentially be demineralised by bacteria—which may also align with increased caries and infections. Of critical note were the locations of dental trauma, as microchipping typically occurred in the posterior teeth for all sexes. Microchipping locations suggest dental trauma in this sample was associated with accidental injury when consuming certain foods (Scott & Winn, 2011), perhaps foods like shellfish, fruit stones, bones, seeds, and nuts that would have been prevalent in both inland and coastal diets (Silberbauer, 1981; Churchill & Morris, 1998; El-Zaatari, 2010; Pargeter et al., 2018). Consequently, and as mentioned, discrepancies between trauma occurrences between males and females were also probably related to higher rates of female AMTL affecting accurate representation of oral conditions from fewer present teeth.

On the other hand, females demonstrated more advanced anterior wear quantity, maxillary anterior oblique and posterior concave wearing, and overall higher incidence rates for non-masticatory wear than males. These findings suggested possible gender-based labour, where females partook activities that frequently used the anterior teeth, although it must be emphasised that the wear quantity regression results between sexes were insignificant, suggesting all sAHGH individuals were functionally using the teeth in similar ways and consuming similar foods. Lukacs and Pal (2016) also suggested similar wear plane angles in HG dentition in Mesolithic (~8800 BP) Damdama from India, which suggested mixed subsistence strategies across sexes. Global archaeological literature with similar non-masticatory wear patterns suggested these activities may have included leather, sinew and plant stripping, hide scraping, running or clutching fibrous materials or circular objects between the teeth (Minozzi et al., 2003; Bonfiglioli et al., 2004; Erdal, 2008; Hylander, 2011; Ricci et al., 2016). Ethnographic studies on southern African Kalahari hunter-gatherers recorded aspects of weaving, threading, and tool making (e.g., bows) as predominantly female tasks of which such tasks would involve gripping items between the teeth (Lee, 1979). Past literature has reported different results between engendered labour (Morris, 1992a; Van Reenen, 1992; Botha & Steyn, 2015), although when assessing such a broad sample over an extended period, group labour expectations likely differed between sites and sAHGH groups over time (Wadley, 1997). These expectations of varying results in a single population have also been demonstrated in global contexts, for example, Littleton and colleagues (2013) assessed South Australian HGH dental wear and reported varying results between site-specific samples of the same population. Females often were reported to have higher anterior wear, but in one of their samples (Gillman group), no females had heavier anterior or premolar wear, yet males did, suggesting inter-regional variation. Additionally, Berbesque and colleagues (2012) reported on dental wear in Tanzanian Hadza HGH, demonstrating different wear asymmetries between sexes that consumed a similar diet, with males eating slightly more meat and females more tubers. The Hadza males exhibited greater asymmetry in the left side of the dentition, whereas females in canines, suggesting males used the teeth to work arrows and bows and females to strip plants based on interdisciplinary observations. Consequently, variability between sexes may be more nuanced when observing a sample holistically.

It can thus be suggested that when considering sAHGH holistically, there were fewer sexual dimorphic oral pathologies and wear than initially assumed, suggesting mainly homogeneous dietary habits throughout the Holocene. This aligns with studies such as Flensborg (2016) on HG remains from Patagonia with similar wear results for sex, also supporting the suggestion that variation in pathology presence was unrelated to wear between sexes. Where there were slight differences, these related to social behaviours that were group-specific and would be better observed in studies employing site-specific comparisons on larger sample sizes. Females contributed to gender-based labour by using their teeth as tools more frequently or in ways that put heavier loads on their front teeth. However, these findings did not provide any implications on how the larger population divided specific tasks nor the quantities of expected labour between sexes; obtaining such results is better suited to ethnographic studies (Lee, 1979; Tanaka, 1980; Silberbauer, 1981).

7.1.2 Impact of age on dental conditions

Age results across all demographic variables (sex, coastal, and temporal) clustered around young/middle, middle, and middle/old adult categories, with the fewest individuals in young and old adult groups. Still, observations for age had a positive correlation between increasing pathology and wear with increasing age-at-death, as expected from past sAHGH studies (Van Reenen, 1992; Pfeiffer et al., 2020). Old adults presented greater odds for both caries and advanced dental wear, yet of greater interest was that numerous individuals exhibited multiple infectious lesions in middle and middle/old-aged life stages, compared to old-aged adults exhibiting fewer lesions. As discussed, sampling bias is the primary consideration for this sample, as young and old adults were underrepresented. Overall, infectious lesions in older age categories, particularly those in more advanced stages, implied that lesions persisted for a while before potentially eventually contributing to an individual's survivorship. Otherwise, lesions in middle and older ages may suggest that some infections may have been asymptomatic, draining intraorally and possibly associated with some intraoral discomfort (McKinney & Olmo, 2022). The moderate number of infections may align with one example in this study of possible dental hygiene practice evidenced by interproximal grooves, suggesting sAHGH may have practised teeth cleaning, reducing the odds of infection. The findings may also align with population-wide resilience into middle and old age as exhibited by EH on the first molars, indicating physiological stress during a vulnerable phase—infancy—collectively demonstrating the resilience and likelihood of HGH individuals surviving into old age without modern medical intervention. Although poor dental health was a leading fatal condition until modern dentistry, contemporary societies typically ingested increased amounts of refined sugars, contributing significantly to poor oral health (Calcagno & Gibson, 1991) compared to HGH populations with healthier oral microbiomes from reduced sugar intake (Mayhall, 1970; Lieverse et al., 2007; Temple, 2016). Consequently, it may be that sAHGH mortality was not grossly inhibited by oral health conditions or dental pathologies during young adulthood, whether it was a biological resilience or efforts to maintain oral hygiene and a diet low in refined carbohydrates.

Young sAHGH adults further demonstrated rapid dentine exposure in the anterior teeth, which suggested that young adults of either sex were required to use the teeth as tools and, thus, expected to contribute to the group in some form of occupational labour from an early age (<18 years). Moreover, the rate of wear, as demonstrated by partial dentine exposure being prevalent in young/middle age groups, supported that the environment and tough dietary components contributed to rapid wear and high abrasion throughout a lifetime. Littleton (2017) assessed dental wear against age categories in a HGH population from Roonka, South Australia; despite the challenges of an inevitable positive correlation between increasing wear with age, dental wear was informative about labour organisation. The authors demonstrated similar findings to this thesis, young adults exhibited similar patterns across the dentition as older adults, suggesting an expectation to contribute to the community from childhood in the form of non-masticatory tasks that utilised the teeth. Moreover, the consistent patterns in wear rates for tooth types across age categories confirm a similar group-wide diet throughout their lives. As such, sAHGH populations may have maintained generally homogeneous dietary habits throughout their lives and amongst their respective groups or families when assessed holistically.

Ultimately, the age results against oral conditions suggested a general increase in oral pathology and wear with each subsequent age category, which met expectations. Notably, instances of infection in older age categories and adults with evidence of EH from infancy suggested large-scale biological resilience. The young adults in this sample also exhibited rapid wear quantity, particularly in anterior teeth, which may imply young individuals in sAHGH communities were required to utilise the teeth as tools from childhood, which suggested an expectation to contribute to the community from an early age. Overall advanced wear quantity also suggested dietary expectations were homogeneous across all age groups throughout an sAHGH individual's lifetime.

7.1.3 Impact of spatial regions on dental conditions

There was a sampling bias across all demographic classifications regarding coastal regions, and fewer individuals represented inland regions, likely due to fewer excavation efforts and recovered remains (Morris, 1992b; Sealy, 2010). AMTL was frequent on the molars for both spatial regions, suggesting similar dietary habits that would instigate pathological conditions resulting in tooth loss, as the posterior teeth maintain functional roles in masticating and grinding food (Górka, 2016). Caries results for coastal teeth aligned with rates reported by Sealy and colleagues (1992) and expected rates for HGH caries (Turner II, 1979; Towle et al., 2021). Inland caries results were much lower than Sealy and colleagues (1992), although the authors reported incidence rates for caries on inland individuals in a much smaller sample (n = 12) which may have inflated caries expression. The higher frequency of caries along the coast *versus* inland in this thesis did not align with caries being reportedly infrequent along the coast (Van Reenen, 1964, 1966; Sealy et al., 1992; Botha & Steyn, 2015) due to cariostatic properties of seafood (Sealy et al., 1992). However, as noted in this thesis and indicated in previous studies, having many individuals from Oakhurst and the surrounding region in a sample may affect caries incidence for coastal samples as caries incidence is higher in the region due to low fluoride content (Patrick, 1989; Sealy et al., 1992). Nonetheless, all caries results remained within mixed economy ranges for HGH populations of 0 – 5.3% reported by Turner II (1979), and more recently, 1 – 5% as reported by Towle and colleagues (2021), therefore, sAHGH caries rates reflected a mixed economy diet. This also aligns with other global HG findings (Bernal et al., 2007; Flensborg, 2016). For example, Bernal and colleagues (2007) reported similar rates on HG from Patagonia, who had a similar diet as sAHGH with respect to having mixed economies that was predominantly plant-based with a high reliance on marine protein and starchy tubers. The author's results were caries rates of 2.75 – 5.25% from Northwest and

Central East Patagonia, and 0.5 to 1.25% from Northeast Patagonia. Whereas Flensborg (2016) reported caries rates of 0 – 5.2% in HG groups from Patagonia throughout the Holocene, despite socioeconomic changes including mobility and demography.

Dental wear quantity was similar between regions and suggested considerable environmental abrasion across regions, aligning with the consumption of tough and fibrous foods with minimal processing (Smith, 1984). As such, these results did not suggest wear was appreciably greater along the coast from grittier marine foods, as suggested by previous studies (Sealy & van der Merwe, 1988; Sealy et al., 1992). Although, Sealy and colleagues (1992) indicated there was considerable variation in seafood consumption along the coast, which may have also affected insights when assessing a large, holistic sample.

Dental wear direction was more insightful than quantity regarding spatial observations. Inland individuals had more frequent oblique wear, which was likely multifactorial: Terrestrial protein may have required the teeth to be in the shearing phase for extended periods (Kay & Hiiemae, 1974; Fiorenza et al., 2018) due to its toughness and higher fat content than softer marine protein, thus, requiring slightly different masticatory regimes that were more intensive further inland (Mays, 2015). Alternatively, inland regions may have demonstrated more abrasive contaminants considering interior biomes are also sandy by nature (i.e., savanna biome, Kalahari Desert), or through food and tool processing techniques such as storage of foods in pits as evidenced at Boomplaas cave (Deacon et al., 1978; Pargeter et al., 2018). Individuals may have also been required to use the teeth as tools in ways that encouraged oblique wearing and abrasive contamination, such as hide or plant stripping (Milner & Larsen, 1991). Microwear analyses may confirm the results of masticatory forces and non-masticatory use of the teeth between spatial groups, where greater force would present with numerous, larger wear pits, and frequent scratches would suggest the presence of softer foods or using teeth as tools (Forshaw, 2015). El-Zaatari (2010) conducted a microwear assessment that included sAHGH occlusal surfaces, but all three samples had coastal provenances, and the results only acknowledged the overall presence of a mixed diet reliant on plant foods.

Environmental abrasion was prevalent among coastal and inland individuals, as evidenced by some uneven wear between cusps, and global HGH dental studies that included spatial variables reported high abrasion from the arid desert (Kaidonis, 2008) and coastal regions (Costa, 1980). Oral pathologies did not demonstrate meaningful results between regions, and overall results exhibited a bias towards coastal individuals due to the sample distribution. Costa (1980) assessed precontact Alaskan populations from three coastal sites at Point Hope, where oral pathologies were similar between sites until subtle changes occurred between groups as a direct effect of changing diet despite inhabiting similar regions. The author reported that the Ipiutak, Point Hope group showed higher caries and abscesses due to different protein sources. The author did not elaborate further, but from more recent research an explanation may be due to higher calculus development from an alkaline oral environment from higher protein intake (Lieverse et al., 2007). Nevertheless, Costa (1980) demonstrated that individuals from similar geographic regions, reliant on similar dietary components, do not inherently imply homogeneous dietary habits, and possible variability between group-based behaviour should be considered.

In line with these investigations, before the spatial findings suggest homogeneous dietary habits, movement and mobility must further be considered regarding similarities between regions in oral health and wear. HGH mobility strategies are discussed in global research because HGH groups tend to depend on the resource structure of the environment (Kelly, 1983), and sAHGH literature has extensively discussed the subject of movement (Stock & Pfeiffer, 2004; Kusimba, 2005; Pfeiffer & Sealy, 2006; Sealy, 2006; Sadr, 2008a, 2015; Pfeiffer & Harrington, 2011). Where coastal groups may have spent more time along the coast due to a steadier supply of marine resources, past research suggested inland groups may have seasonally visited the coast (Mazel, 1987; Parkington, 2001), although, over the last few decades, sAHGH mobility continues to be contested. Sealy (2006) suggested that mobility between coastal sites was more limited than initially assumed, and groups were not organising occupational movements around resources. Yet, in broader HGH theory, HGH groups were already accustomed to logistical mobility in the form of extended or multi-day movement for hunting or foraging expeditions (Binford, 1980). As Forssman (2019) discusses, the belief that HGH were tethered to the environment has been challenged when considering mobility from a biocultural framework. Although some residential mobility is affected by environmental aspects that studies have reported to affect past populations in southern Africa, particularly during the middle Holocene such as climate or seasonal changes and resource scarcity (Kusimba, 2005; Pfeiffer & Sealy, 2006; Ginter, 2011; Lander & Russell, 2018). Fluctuations in population movement over time have also been noted globally; Stojanowski and Knudson (2011) elaborated upon environmental adaptation with increasing palaeomobility upon the introduction of herding in early Holocene Saharan HGH. When herding became an integral part of sAHGH livelihood from 2000 BP, it likely did not occur in a unilinear process (Sadr, 2015); sAHGH individuals may have strategically optimised on seasonally specific situations, such as seasonal food shortages, that encouraged movement, or been displaced by certain groups who picked up herding (Parkington, 2001). It has been noted in late 19th and 20th century San and/or Khoe individuals by Botha and Steyn (2016) that groups participated in seasonal movement between farms and the veldt to take advantage of the seasonal availability of certain foods. Therefore, this behaviour remains plausible, although potentially on a smaller scale that did not contribute to appreciable differences between wear and oral health in this larger sample, nor affect overall dietary markers such as isotope signatures (Sealy & van der Merwe, 1986). Movement may have been practised to maximise on certain foods (Botha & Steyn, 2016), find fresh water (Jerardino, 2003), or tend to herds by moving about a landscape in search of seasonal pastures (Sampson, 2010).

Although this study sample exhibited a bias towards coastal remains with an overall reliance on marine protein as opposed to terrestrial mammal protein for inland groups, the findings followed the same general patterns across the dentition. These considerations may imply similar overarching dietary preferences. Therefore, it is suggested that the macroscopic observations between spatial regions supported past studies suggesting that the sAHGH diet was composed of plant foods and subtle variations were either due to small-scale movements or merely sampling bias. As such, the findings may suggest sAHGH dietary preferences were relatively homogeneous for both coastal and inland groups when observed broadly, particularly regarding the reliance on tough and fibrous plant foods and the presence of heavy environmental abrasion from both regions. Future detailed assessments (e.g., microwear) that include more inland individuals may provide more nuanced insights.

7.1.4 Impact of temporal periods on dental conditions

The introduction of herding from 2000 BP was a turning point for sAHGH livelihood (Deacon et al., 1978; Sadr, 2003, 2004, 2008a; Ginter, 2011; Russell & Lander, 2015), along with the migration of Iron Age agropastoralists which gradually affected sAHGH occupation in the east of South Africa (Choudhury et al., 2021). Earlier Holocene results were more underrepresented in this sample, and sampling bias must be acknowledged, as fewer individuals dated to this time. However, the findings in this study broadly suggested a relatively homogeneous diet throughout the Holocene (between pre and post-2000 BP), yet there were subtle improvements in oral health during the later Holocene when compared directly with the middle Holocene. Where AMTL, caries, and infectious lesions did not present significant results over time, similarly reported by Gibbon and Davies (2020), the number of teeth affected by all these conditions presented interesting results. There were about the same number of individuals affected by the abovementioned conditions in both the middle and later Holocene; however, more teeth were affected, and lesions were more prevalent in the middle Holocene. Increased caries in the middle Holocene has also been noted by Black (2014). In this thesis, sampling bias must first be acknowledged between these periods, as there were slightly more individuals and teeth present in the middle (individuals: n = 137; teeth: n = 2356) *versus* later Holocene (individuals: n = 113; teeth: n = 2086), although insignificantly. Additionally, between Holocene divisions, an almost equal number of individuals were affected by caries, for example, despite the slight increase in individuals in the middle Holocene sample. Relative frequencies of age category distributions between the middle and later Holocene were also relatively similar and did not exhibit statistical significance (Appendix C: Table C4). Therefore, sample distribution may be exempt as an explanation for the increase in oral pathology. Rather, these observations may support nutritional insecurity during the middle Holocene from rapid population-growth resource scarcity (Sealy & Pfeiffer, 2000; Pfeiffer & Sealy, 2006), where a weakened immune system from inadequate nourishment may make the body susceptible to additional pathology (Regezi, Sciubba & Jordan, 2017).

Clarke (1999) and Calcagno and Gibson (1991) broadly reported that oral diseases were a leading cause of death before medical intervention, and the extreme, detrimental effects of dental diseases only began to be directly addressed through extensive dental surgery in the late 19th century. Additional archaeological studies have assessed pathology development in malnourished individuals; for example, DeWitte and Bekvalac (2010) examined the relationship between periodontal disease and caries with mortality risk in a Mediaeval English sample. They found that oral conditions were positively associated with elevated mortality risk, where individuals with either condition were more likely to die from additional systemic health problems than adequately nourished individuals.

Dental plasticity may have also affected the increased lesions, as malnutrition may affect tooth size (Black, 2014). Stynder (2006) and Hausman (1980) found little craniofacial variation from around 2000 BP, although there was a slight increase in size. Sofaer (1973) discussed that a reduction in face and jaw size can result in a reduction in tooth size, although this is not always the case and may not apply to sAHGH dentition, as Black (2014) reported earlier and middle Holocene teeth remained morphologically similar in proportion to a smaller body size. The author further reported that most morphological differences were noted within the later Holocene and any temporal variations were a product of increased sample size from the middle Holocene or within-population variation. Overall, their results suggested dental homogeneity over time. Therefore, though tooth size affecting lesion counts should be considered, it may not have significantly affected these results. As such, it is speculated that mortality risk may have also been higher in the middle Holocene, as demonstrated by increased pathological lesion rates per individual, in the form of dental decay.

Besides mortality risk in the middle Holocene, post-2000 BP improvements may have been due to a transition to increased delayed-return subsistence strategies upon the introduction of herding and new food processing techniques that reduced overloading the teeth for non-masticatory purposes, reducing the instigation of additional pathology. Adapting processing techniques may have reduced localised abrasion and microfracturing, compromising the tooth's integrity to decay further or other conditions, as fewer individuals and teeth were affected by dental trauma in the later Holocene. Altered tool types or food processing techniques were also due to an increased likelihood of oblique wear pre-2000 BP. The use of grinding stones increased in post-2000 BP (Sadr, 1998, 2008a; Copley et al., 2004), which would have contributed to softening food properties and abrasion from the grinding of the stones themselves (Smith, 1984; Fiorenza et al., 2018). Furthermore, ceramics increased in prevalence from this period following the introduction of herding, which meant techniques such as boiling and cooking became more prevalent, thus, softening the composition of tougher or brittle foods (Sealy, 1984; Copley et al., 2004; Lander & Russell, 2020). Considering softer foods from increased processing are more often affiliated with increasing oblique wear (Smith, 1984; Esclassan et al., 2015; Grimoud & Gibbon, 2017), these aspects may be correlated. Notably, enamel hypoplasia was an exception to later Holocene health improvement, where EH has a physiological aetiology as opposed to being directly affected by dietary choices or oral hygiene. The first molars were the second-most affected teeth in the later Holocene, which suggested physiological stress also occurred in infancy, an age earlier than what past literature has reported (two to four years of age) (Konner & Worthman, 1980; Clayton, Sealy & Pfeiffer, 2006; Gibbon & Davies, 2020). The transition into a new lifeway would have introduced adaptation difficulties, possibly resonating the most with pregnant sAHGH women, as discussed by Pfeiffer and colleagues (2014). The authors reported mortality risk doubling for young women due to parturition in post-2000 BP, which aligns with this study's findings of infant stress as demonstrated by the first molar demonstrating the second-most incidence rates for EH during the same period. Global findings such as those by Flensborg (2016) suggest similar explanations, where similar distributions of EH as caused by physiological perturbations between 2 – 4 years of age throughout the Holocene in Patagonian HG groups were likely due to the weaning process of replacing breast milk with solid food. However, the prevalence of EH in the adult sample suggested a good survival rate. The rates were 50% in the initial later Holocene, and improved to 27.6% in the final later Holocene, also suggesting changing social organisation practices did not greatly affect the health of a HG individual (Flensborg, 2016).

Dental wear was consistent throughout the Holocene, and ethnographic findings have noted that sAHGH maintained a plant-dominant diet into contemporary periods (Lee, 1979; Tanaka, 1980; Silberbauer, 1981; Kelly, 2013). However, isotopic literature has reported slight dietary changes throughout the epoch, such as coastal groups incorporating more terrestrial foods post-2000 BP (Sealy & van der Merwe, 1988). These results demonstrated that despite potential dietary changes, similar wear patterns were reflected in pre-2000 BP, suggesting an insignificant shift in diet when assessing the sample holistically. Where the diet was largely homogeneous and maintained a high amount of fibrous plant foods, this may suggest small-scale dietary variations were occurring in some sites but not consecutively within all groups (Sealy & van der Merwe, 1988). Moreover, introducing food processing in the form of grindstones from 2000 BP would have introduced more abrasive contaminants from the stone grinding upon itself (Deter, 2009). Ultimately, past studies on global HGH remains, such as Costa (1980) and Mayhall (1970), demonstrated that variation in dental wear and pathology in HGH populations typically become notable only upon major shifts in diet, such as with the introduction of refined carbohydrates (starches and sugars) often correlated with the colonisation of a region (Mayhall, 1970; Costa, 1980; Botha & Steyn, 2015). These sorts of dietary shifts were further demonstrated in southern Africa through oral pathologies as reported by Botha and Steyn (2015), who compared contact period hunter-gatherer to farm-labourer San and/or Khoe remains demonstrating greater dental pathology for those who began consuming items such as maise meal and sugar. Global findings such as those by Bernal and colleagues (2007) have been similar in HG diets from Central East, Northwest, and Northeast Patagonia predominantly consuming plant-foods. Generally, reduced wear rates when investigated alongside consistent caries ratios suggested temporal changes in wear were more likely due to changes in processing methods over the type of subsistence.

The archaeological record has demonstrated that the introduction of herding brought about new foods and processing techniques, such as dairy and grindstones. However, these results did not demonstrate appreciable differences between periods that would otherwise suggest introducing completely new dietary staples or food consistencies, and any new additions were introduced gradually while sAHGH maintained similar lifestyles and broad dietary habits. Across the Holocene, regardless of spatial and temporal divisions, the teeth showed consistent evidence of habitation in heavy wear environments with lower physiological stress, apart from examples of EH suggesting increased physiological stress in later Holocene infants, possibly related to parturition and lifeway adaptation challenges. Of note, however, was that oral health was markedly worse during the middle Holocene, demonstrated by increased lesions for AMTL, caries, and infectious lesions, and this was potentially associated with elevated mortality risk, if not leastwise additional co-morbidities from a period of resource scarcity and increased population sizes.

7.2 Implications for sAHGH research

The implications of this study, and for wear and dental pathology studies in general, are two-fold. By assessing oral health conditions and dental wear separately, the multifactorial nature of each condition was independently assessed, resulting in nuances in sAHGH health and behaviour through the Holocene. Moreover, independent assessments also highlighted their limited nature, confirming an inevitable interaction between oral conditions and processes that elaborated on aspects of dietary and socio-cultural habits. This interplay of masticatory mechanisms and oral pathologies, exacerbated by aspects of environmental contexts (low water fluoride, selective resources), individual co-morbidities (hereditary and physiological conditions), and non-masticatory uses of the teeth (tool use and parafunctional habits), simultaneously contributed to inferences on overall health and behavioural habits of sAHGH individuals.

The teeth of sAHGH individuals were collectively affected by AMTL, caries, infectious lesions, and rapid dental wear. Where incidence rates for dental decay were lower in HGH teeth compared to pre-colonial agriculturalist teeth (Turner II, 1979; Eshed, Gopher & Hershkovitz, 2006; Kaidonis, 2008), prolonged mastication resulting in advanced dental wear was a primary expectation in sAHGH populations, and many teeth in this study displayed moderate dentine exposure by an early age and wear-caused pulp chamber perforations. These findings demonstrated that the relationship between tooth loss, infectious lesions, and dental wear were just as important as the more frequently reported relationship between caries and tooth loss (Costa, 1980), and where the pulp was already exposed, developing infectious lesions were highly likely (Reichart, Creutz & Scheifele, 2007; Rufino, Ferreira & Wasterlain, 2017). The relationship between dental wear and oral pathologies was supported by increased odds of tooth loss and pulpal exposure for anterior teeth, of which caries and anterior teeth did not reflect meaningful effects.

7.2.1 Dietary influences

General dietary expectations for sAHGH have most frequently been due to isotopic studies (Sealy, 1984, 2006, 2010; Sealy & van der Merwe, 1988; Sealy & Pfeiffer, 2000; Stock & Pfeiffer, 2004; Pfeiffer et al., 2019), archaeological material (Drennan, 1937; Sampson, 1974; Deacon et al., 1978; Deacon, 1984, 1995; Bollong, Sampson & Smith, 1997; Deacon & Deacon, 1999; Sadr & Sampson, 1999; Mitchell, 2002; Sadr, 2008a,b; Lander & Russell, 2018) and ethnographic studies (Lee, 1979; Tanaka, 1980; Silberbauer, 1981). Although the introduction of herding from ~2000 BP was a turning point for sAHGH populations, the findings from this study suggested a relatively homogeneous diet throughout the Holocene concerning a greater reliance on fibrous plant foods, although with subtle improvements in oral health post-2000 BP. These later Holocene improvements may have been related to food security rather than gross dietary changes, as sAHGH health may have improved with the introduction of additional food options through the introduction of herding (Pfeiffer, 2007). Advanced wear quantity and horizontal and plane directions also supported expectations of a mixed economy that predominantly consisted of tough and fibrous plant foods based on comparisons to past literature exhibiting similar characteristics (Smith, 1984; Kieser et al., 2001; Kaifu et al., 2003; Deter, 2009; Fiorenza et al., 2018). Where these data cannot provide information on variations in protein consumption between regions, isotope studies have elaborated on protein types varying between spatial regions (Sealy et al., 1992; Sealy, 2006, 2010; Lewis & Sealy, 2018; Pfeiffer et al., 2020). As such, the dental wear results from this study suggested a macroscopically observable reliance on carbohydrates above proteins. Past work noted that sAHGH also consumed plant products with high nutritional value in the form of vitamin C and protein, such as mongongo nut, marula fruit, and baobab (Lee, 1979; Tanaka, 1980; Botha & Steyn, 2015), supporting the idea that sAHGH individuals managed to maintain good nutrition despite the inhabited region (i.e., coastline or desert). Although macrowear can only elucidate gross dietary habits, a microwear study by El-Zaatari (2010) on a small coastal sAHGH sample supported these findings, as their results also exhibited a mixed but generally homogeneous diet between sites.

Concerning a diet largely composed of carbohydrates with tougher consistencies, past research on caries reported that HGH teeth have fewer occlusal caries because the occlusal surfaces, cusps, and grooves wear away faster in heavy wear populations (Larsen, 2015). Calcagno and Gibson (1991) discussed this theory and reported that correlations with decreased caries in populations with smaller teeth were due to already simplified occlusal morphologies, potentially permitting greater resistance to occlusal caries regardless of dental wear. Kaifu and colleagues (2003) also investigated this theory in archaeological remains and determined that dental wear cannot solely ensure protection from caries on specific tooth surfaces, and caries rates and locations are multifactorial.

Where researchers directly assessed the caries-attrition complex on contemporary archaeological remains in other global contexts, caries incidence rates appeared to vary between studies. Maat and van der Velde (1987) presented negative correlations on Dutch whalers dating to the 17th and 18th centuries; lower occlusal surface caries were associated with higher wear. Conversely, Meiklejohn and colleagues (1992) assessed this previous study against a more ancient sample, a Portuguese Mesolithic population. The authors found a positive correlation between high caries and dental wear, suggesting that negative correlations between caries and wear are not universal. They concluded that caries-attrition findings were neither due to caries nor dental wear being directly dependent on each other. Instead, caries rates correlated with dietary preferences and particular dietary practices, and an interplay amongst such aspects will demonstrate different relationships between the variables.

When considering wear quantity and caries, partial dentine exposure was the mean wear stage for this and past sAHGH studies (Drennan, 1929; Morris, 1992a; Sealy et al., 1992; Van Reenen, 1992). Partial dentine exposure is a stage that would still retain most of its primitive form and volume via persisting occlusal cusps and grooves. Lieverse and colleagues (2007) argued that severe dental wear obliterated interproximal contact areas, permitting interdental food retention, and resulting in rapid bacterial growth. Therefore, I suggest occlusal caries were infrequent in HGH dentition, not because the grooves and fissures have worn away, but as Lieverse and colleagues (2007) suggested, the interproximal regions became more susceptible to bacterial growth. As a result, proximal caries surpassed occlusal caries in frequency.

sAHGH literature has also demonstrated varied caries incidence results, where Riet River skeletons, as examined by Morris (1992a), exhibited heavy occlusal wearing and ‘high’ caries. The sample from this thesis demonstrated moderate caries rates, occurring more frequently on proximal regions than occlusal surfaces. This study's caries incidence rate per individual was 28% (102/369) and fell between a wide range of caries rates of 17.7% and 52% in other published sAHGH studies (Sealy et al., 1992; Gibbon & Davies, 2020). These results demonstrated low, moderate and high caries incidence variation between sAHGH studies, likely related to demographic aspects and interindividual variation. It may be that the wide variation between results on sAHGH caries is representative of mixed economies, as stated by Turner II (1979), who suggested that moderate frequencies of carious teeth will vary between those reliant on protein (Costa, 1980) versus agriculture (Lukacs, 1992). Where sAHGH consumption of 'terrestrial' foods has varied, as evidenced through stable isotope analysis between sites near each other (Sealy & van der Merwe, 1988; Sealy, 2006), carbohydrate consumption would be expected to vary between groups. Diversity between consumption practices between groups is a valid aspect to consider as discussed by Marklein and colleagues (2019), which may explain the variability in caries variation between groups and published literature.

Oral pathology on sAHGH was moderate, which aligned with global HGH expectations. Due to the aetiology of caries and wear being largely related to diet, these conditions readily demonstrated potential dietary influences. Generally, sAHGH maintained a mixed and likely homogeneous diet across space and time, and varying caries rates across studies suggest slight variation in carbohydrate to protein consumption between groups, supporting past literature of sAHGH maintaining mixed diets. As such, there was likely some variability in food sources between groups, although when sAHGH are broadly assessed, the diet of southern Africa was largely mixed.

7.2.2 Cultural and individual behaviours

This study cannot determine whether hygiene significantly contributed to moderate pathology expression in sAHGH populations; however, the individual case of interproximal non-masticatory grooving demonstrated that dental care may have been an observed practice. Past studies have regarded HGH oral health to be generally 'good' (Turner II, 1979; Morris, 1992a; Deter, 2009), although agriculturalist populations, noted for poor oral health, typically serve as the comparative standard in the literature (Smith, 1983, 1984; Lukacs, 1992; Larsen, 1995; Eshed, Gopher & Hershkovitz, 2006; Watson, 2008; Deter, 2009; Temple, 2010; Price & Bar-Yosef, 2011). Dental decay incidence has frequently been accredited to the consumption of cariogenic foods, such as refined carbohydrates in the form of starches and sugars (Larsen, 2015), that tend to be introduced into a region through agriculture or colonisation (Botha & Steyn, 2015). However, oral hygiene techniques are worth considering as studies have recently been redirecting attention to early evidence of oral hygiene (Bonfiglioli et al., 2004; Oxilia et al., 2015, 2017; Ricci et al., 2016). As reported in Chapter 5, an individual case of possible dental pick grooves was observed in an individual dating to the earlier Holocene, highlighting the possibility of dental hygiene in sAHGH. Pfeiffer and colleagues (2020) are the only other known sAHGH study that looked into wear patterns reflecting dental care behaviour, but they did not find any instances. It must be stressed that their sample was small (*n* = 14) and the individuals were recovered from a single burial site in Cape Town and cannot reflect the larger population. Other global precontact examples for early pathological intervention appeared as 'drilling' to remove infected tissue, beeswax 'fillings', and dental picking (Oxilia et al., 2015, 2017), which apart from dental picking, were not observed in this sample. Additional to pathological intervention, Van Reenen (1964) mentions San and/or Khoe would rub ash over the teeth and gums or chew shrub twigs to clean the teeth. This was a common practice and is reported globally. For example, Lovell and Palichuk (2019) discovered evidence of dental care in an Egyptian woman dating to over 4000 BP, who likely used ash, sand, and frayed plant stems to clean the teeth. Therefore, dental care behaviour was likely prevalent in numerous ways and may be an assumed individual behaviour for sAHGH.

This study also demonstrated interindividual variation in cases of non-masticatory wear that presented individualised cases of using teeth as tools. Current literature has widely discussed sAHGH tool use in archaeological (Deacon, 1974; Deacon et al., 1978; Sadr, 1998, 2004, 2008a, 2015; Kusimba, 2005; Lander & Russell, 2018), bioarchaeological (Van Reenen & Briedenhann, 1986; Van Reenen, 1992; Botha & Steyn, 2015; Gibbon & Davies, 2020), and ethnographic studies (Lee, 1979; Tanaka, 1980; Silberbauer, 1981). However, sAHGH dental studies have not yet extensively presented characteristic examples or discussed non-masticatory wearing as evidence of using teeth as tools. The implications of tool use in this study, exemplified through descriptively and visually presenting characteristics, supported past archaeological and ethnographic observations on tools and occupational activities. Using teeth as tools in precontact populations is a global phenomenon (Larsen, 1985; Brown & Molnar, 1990; Milner & Larsen, 1991; Alt & Pichler, 1998; Hattab & Yassin, 2000; Bonfiglioli et al., 2004; Eshed, Gopher & Hershkovitz, 2006; Erdal, 2008; Hylander, 2011; Lovell & Palichuk, 2019), and thus, special care should be applied in future sAHGH dental studies in identifying wear patterns in an attempt to narrow down potential tasks.

Overall, broad investigations into sAHGH elucidated likely individual behaviours. Where only one individual demonstrated possible dental care, southern African ethnographic work has noted behaviour in maintaining oral hygiene. The individual case observed in this thesis suggests that oral hygiene maintenance may have occurred as early as the earlier Holocene in southern Africa. Moreover, this thesis confirmed using teeth as tools through non-masticatory wearing. Where it is challenging to identify the precise behaviours involved with the wear patterns, examples of labour-based markers on the dentition are hereby confirmed and would benefit from further, isolated research in future works using additional techniques such as microwear analyses.

7.2.3 A thriving population

The literature has already determined that mid-childhood may have been one of the most biologically stressful periods for a young sAHGH individual (Pfeiffer, 2007) and EH on the first molars in the later Holocene highlighted additional physiological stress during infancy or early childhood. Over time, the health of foragers may have improved from post-2000 BP with new food processing techniques, dietary options (dairy), and increased food security. With these transitions, there was also the introduction of new pathogens and group conflict that may have had a negative effect (Pfeiffer, 2007). This study's observations on temporal periods suggested that post-2000 BP exhibited improved oral health through a reduction in lesion incidence for AMTL, caries, and infectious lesions. These results may be associated with adjustments to ecosystem management and food security but with no overarching changes in the types of food consumed, albeit some coastal sites incorporated more terrestrial products based on earlier literature (Sealy & van der Merwe, 1988).

Conversely, increased EH on the first molars in the later Holocene was a period of adaptation, possibly due to dietary adjustments following an extended period of resource scarcity in the middle Holocene. These findings were exemplified by comparatively poorer health in the middle Holocene during a notably stressful period due to population growth across southern Africa. Additionally, these results may have been isolated to groups without livestock, who were marginalised and forcibly displaced from coastal regions further inland, thus, facing additional adversity from forced relocation (Mazel, 1987). However, despite the increase of EH at younger ages and an adjustment period, these data highlighted sAHGH resilience while being faced with various adversities due to climatic reasons, rapid population growth, parturition, dental co-morbidities, socio-cultural factors, or an unforgiving landscape.

Although incorporating multiple techniques (e.g., imaging methods) is ideal for mitigating missing data, it is stressed here that macroscopic observations remain effective and crucial to elaborate on population-wide health and behaviour, as demonstrated by acknowledging different types of macroscopic cysts and abscesses. Identifying these lesions was critical to inferences drawn as they provided information on the severity of the infection and potential contributions to mortality and morbidity. The presence of infections can contribute to a plethora of additional complications, if not simply septicaemia. Maxillary infections may result in cavernous sinus thrombosis or meningitis from infection of the cranial cavity through the facial vein or the internal pterygoid plexus of veins. In contrast, mandibular infections can result in Ludwig's angina, leading to asphyxiation, endocarditis, or pneumonia (Calcagno & Gibson, 1988, 1991). However, an infectious lesion can also be both asymptomatic and benign (Forshaw, 2014) and, as demonstrated through these findings, can have no observable correlation with additional oral health conditions (non-odontogenic cysts). It was already acknowledged that this study likely underestimated acute abscess presence, but individual case reports of non-odontogenic cysts have not yet been reported in the literature for sAHGH individuals. The presence of different types of infectious lesions in this study sample represented examples of human resilience, as demonstrated through age-related observations where sAHGH individuals lived to middle- and old-age despite a moderate frequency of advanced infectious lesions.

These findings further supported strong physiological resilience through examples of adults with conditions such as gross facial cysts, amelogenesis imperfecta, and physiological stress occurring as early as infancy. This study's findings demonstrated that there was more at play regarding oral health for sAHGH populations and potentially HGH groups entirely due to cultural behaviours and individual hygiene habits. Where dental diseases were a leading cause of death before the 19th century (Calcagno & Gibson, 1991; Clarke, 1999), oral hygiene practices may have reduced the development of or rate of dental diseases (Frayer & Russell, 1987). Moreover, an ethnographic study by Lee (1979) on southern African hunter-gatherers inhabiting the Kalahari indicated that the hunter-gatherers appeared to be well-nourished, typically exceeding their required daily caloric intake and supplementing protein with high-protein plant foods, therefore, maintaining a balanced diet even in the arid interior of a desert biome. Milton (2000) investigated various hunter-gatherer diets and concluded that the dietary behaviours of various HGH populations varied widely and did not fall under one standard macronutrient pattern that society today considers ideal for maintaining good health. The author indicated that dietary energy in southern African HGH, for example, is supplemented by wild plant foods, and a population's evolutionary history relative to their environment and cultural behaviour shapes certain groups' nutrient requirements and digestive physiology. Cultural behaviours also played a role, where today, we are acclimatised to processing foods, thus 'predigesting' food using technology. Milton (2000) suggested that selective foods and the digestive physiology of a population play a more prominent role in the reduced presence of diseases and a good survival rate or biological resilience in HGH populations against environments that modern individuals consider harsh.

Chapter summary

The data and independent discussions from earlier results and discussion chapters were compiled here to elaborate upon broader findings and their larger implications when observing the effects of the interplays of multiple oral processes to demonstrate the multifaceted nature of these observations when considered against other oral factors at play. This chapter included a broader discussion of these results as they pertain to demographic observations to investigate the interactions between sex, age, space, and time against oral health and dental wear. The subsequent section discusses the implications of sAHGH research against broader comparisons and as related to the aims of this thesis. This general discussion was structured to acknowledge the aims of this thesis: impacts of demographic factors, dietary habits, and individual and cultural behaviours, and to support current theoretical approaches to HGH research by discussing how past peoples thrived in their environments. This thesis concludes in the next chapter and includes a novelty statement and suggestions for future research.

CHAPTER 8: CONCLUSIONS

In this thesis, dental macrowear quantity, direction, and oral pathology in archaeological sAHGH over the Holocene were explored and analysed to determine environmental and behavioural impacts on the dental condition. Research has shown that there has been cultural variation throughout the Holocene in behavioural and dietary transitions and periods of extended resource scarcity and rapid population growth during the middle Holocene. While numerous studies have reported on various aspects of sAHGH dentition, there has not been a published study that conducted a systematic macroscopic assessment of the interrelated effects of dental wear quantity, direction, and pathology across time and space. The multifactorial nature of the sAHGH dental condition and behaviour were discussed by integrating these lines of evidence, which all influence the development of further pathology and dental characteristics such as non-masticatory wear. My study contributes to the field by providing a holistic understanding of sAHGH changing behaviour and health using non-destructive and non-invasive methodologies on a relatively large sample.

In this thesis, I focused on: (1) The impacts and interplay of demographic factors, such as sex, age, space and time, against dental wear, pathology and masticatory mechanisms; (2) The influence of diet and an environment on a population's dental condition; and (3) The extent where cultural and individual behaviour impact dental patterns of macrowear and pathology during the southern African Holocene. The results indicated that many general dietary requirements were homogeneous across the landscape and developed collectively with the transition to herding, potentially supporting mobility. However, fluctuations in these results highlighted individual cases of varying environmental resilience, possible oral hygiene habits, and non-masticatory uses of the teeth.

Sampling bias was prevalent on a large sample set, where individuals from coastal regions and young/middle-adult ages preserved better than any other group in their category. Macrowear quantity advanced rapidly, particularly on the anterior and first molar teeth, aligning with expectations from HGH global research. Where this aligned with tooth eruption timing, as on the first molars, this thesis demonstrated that the overloading of the anterior teeth was likely related to using the teeth as tools, and all sexes and ages similarly utilised the teeth. Young adults, comparatively, were expected to contribute at an early age, as also demonstrated by rapid anterior tooth wear. Wear direction, which past research has not yet addressed for sAHGH teeth, demonstrated a predominance of horizontal and plane. This result aligned with global research correlating flat wear with a tough and fibrous diet, typically involving plant foods. This further correlated with other research on the sAHGH diet, which indicated a reliance on plant foods over protein components. Where deviations from this predictor were observed, oblique and concave wear directions demonstrated probable tool use, for plant and hide stripping, and increased abrasion, higher in the interior of southern Africa, but still prevalent across the entire landscape.

Generally, oral health was good, but the first molar was most frequently affected by dental decay, wear, and AMTL, and this was likely due to its early eruption time and an additional interplay of conditions, predisposing the teeth to additional diseases. Post-2000 BP was notable regarding health, as pathological lesions for dental decay and AMTL reduced, suggesting a health improvement potentially associated with the transition into herding. Conversely, EH on the first molars increased, alluding to heightened infant stress in the later Holocene, possibly related to nutritional deficiencies in parturition upon the transition into a new lifeway or the gradually forced displacement of certain groups away from the coast. The presence of conditions such as AI, non-odontogenic cysts, and high dental decay rates in low-fluoride regions demonstrated that certain individuals experienced increased stressors on the physiological body, resulting in comorbidities. However, the age groups of these individuals in older categories suggested a reasonable rate of survival despite any present conditions, which suggests a satisfactory level of biological resilience.

I amalgamated key findings from three avenues of analysis: dental wear quantity, direction, and oral pathology, to broadly investigate the multifactorial nature of sAHGH dentition and behaviours. The results of this thesis support resource-sharing practices and broad labour-based contributions regardless of the developmental stage between sexes. Although inter-site variations are relevant, this study has attempted to contribute to understanding general dietary and socio-cultural behaviour through macroscopic means. The application of macroscopic methods and the inferences from the findings affirmed the applicability and usefulness of macroscopic observational analyses to glean biocultural insights. A large sample set enabled investigations into large-scale behaviours, and future studies can concentrate on aspects that varied from previous expectations. The regionally distinct sAHGH population, composed of the oldest HGH populations of modern humans, is an excellent example of long-term and large-scale adaption to a fluctuating environment. This thesis emphasises the capabilities of ancient populations thriving in these environments, and this study was globally innovative for the continued application of non-destructive methods in dental anthropology.

8.1 Novelty statement

This research project was the first to apply a multimethod approach using dental wear quantity, direction, and oral pathologies on sAHGH dentition whilst directly assessing the results against demographic variables of sex, age, spatial, and temporal divisions. This project accomplished this aim through a systematic assessment of macroscopic dental examinations. Although previous sAHGH research has included dental wear (Van Reenen, 1964, 1992; Sealy & van der Merwe, 1988; Morris, 1992a; Sealy et al., 1992; Pfeiffer & Sealy, 2006; Gibbon & Davies, 2020; Pfeiffer et al., 2020), the inclusion of direction was novel as past research had not addressed this on sAHGH teeth, despite being a notable aspect of examination in other HGH populations (Molnar, 1971; Smith, 1984; Kieser et al., 2001; Kaifu et al., 2003; Gibbon & Grimoud, 2014; Grimoud & Gibbon, 2017). Moreover, a novel contribution to dental anthropology was creating and presenting a revised Brabant index inclusive of multicuspid scoring and a visual guide, which greatly improved method repeatability for experienced observers. This study demonstrated that macroscopic methods remain effective in analysing the interplay of masticatory mechanisms against demographic and individual variables. Moreover, as sAHGH is a regionally distinct population and thus occupies a key position for HGH anthropological assessments, this research contributed to holistic inferences on sAHGH health, diet, and behaviour through the direct analyses of the population against the environment. This study emphasised the microevolutionary history of a regionally distinct African population whilst remaining globally innovative as it demonstrated that sAHGH is one of the oldest HGH populations of modern humans (Schlebusch & Soodyall, 2012), and is a good adaptive representation for non-destructive and non-invasive dental analyses.

8.2 Future research

A holistic assessment of dental macrowear and health in sAHGH dentition provided observations into overall health, dietary, and behavioural habits throughout the Holocene. These findings have raised additional questions which may provide promising avenues for future research. As previously mentioned, for more precise comparative standards, the sample distribution is notably lacking for age groups and inland regions. As highlighted by Malek (2022) and several past studies (Pfeiffer, 2011, 2012; Botha & Steyn, 2016; Gibbon & Davies, 2020), there are currently no standards for accurate age estimation on sAHGH individuals, and some age estimates spanned multiple categories due to the ambiguity of morphological characteristics or poor skeletal preservation. Efforts to redefine age-estimation standards that cater to the uniquely small-bodied morphology of sAHGH individuals would narrow the broad age estimates (e.g., young/middle adults and middle/old adults). Although uncovering more sAHGH individuals further inland is essentially out of a researcher's control on numerous levels, collaborations between southern African repositories within South Africa and neighbouring nations may increase the spatial distribution of archaeological sAHGH populations.

This study made possible the reassessment of the Brabant index, a frequently implemented dental wear method, improving its reliability and accuracy through the creation and presentation of an optimised index, as demonstrated by observer assessments. Adjustments to the standard used, such as multicuspid scoring and visual aids, should be implemented on global archaeological populations to obtain direct comparative standards for HGH dental wear. Applying this improved index to additional populations, both HGH and otherwise, would be informative in determining direct similarities or differences for various archaeological contexts. A larger-scale assessment would provide additional insights into whether aspects, such as introducing a new lifeway, demonstrated similar results in the rate and direction of wear. Moreover, reassessing the rate of wear from the initial assessment of wear rates by Van Reenen (1992), by using principle axis analyses (Bernal et al., 2007) or regression testing (Bartholdy, Hoogland & Waters-Rist, 2019; Olszewski, 2019) may elucidate how 'heavy' the heavy-wear environment was for sAHGH dentition. Incorporating additional detail in qualitative research is advisable, and documenting the presence of a visible hole in the dentine when observing pulpal exposure is one potentially valuable observation for researchers studying wear rates. Including non-adult dentition would be of additional importance to confirm whether parafunctional habits using teeth and abrasive contamination in the diet were as prevalent in children as in adults.

As previously mentioned, a systematic and combined assessment of sAHGH oral pathology and dental wear had not yet been conducted, where dental wear direction as a primary aim has never been reported on sAHGH dentition. Future studies that elaborate on these findings using the same techniques employed here, albeit on global populations, would provide good comparative data that takes advantage of a holistic approach to elucidate biocultural nuances. The sample assessed here included a diverse set of skeletal remains from various contexts that have been greatly affected by weathering and poor preservation, and some contexts would have been underrepresented (i.e., spatial regions and age estimates). Where aspects such as this are out of a researcher's control, applying these objectives using this study's methods to additional populations with similar demographic contexts (e.g., sub-Saharan HGH remains) may provide alternative angles of interpretation where archaeological remains are unavailable or in too poor condition for assessment within southern Africa. Incorporating edentulous jaws into the inclusion criteria may provide supplementary insights on maxillofacial pathology, while simultaneously expanding the sample size.

Curious insights that may be elaborated on further included assessments of dental wear direction. Although the findings in this study overwhelmingly coincided with horizontal and plane wear expectations as reported for both sAHGH and global HGH individuals, deviations from this standard noted isolated cases which were suggestive of individual parafunctional habits or, potentially, spatial variation. Although El-Zaatari (2010) reported on microwear for a small sample of sAHGH individuals, a similar approach as in this thesis would prioritise a systematic assessment of microwear and include more variables, such as spatial regions, or biomes, and would identify nuances in dental wear direction. Smaller assessments on microwear variations in those with non-masticatory wear may elucidate whether different facets are from parafunctional habits and otherwise from mastication or stress (Kaidonis et al., 2012).

The enamel hypoplasia findings elucidated other periods of physiological stress during childhood that past research has not yet reported. Conducting a detailed assessment of these findings by including non-adult individuals would provide more insights into sAHGH childhood. Investigating further into hypoplasia in this sample was out of the scope of this research; however, supplementary analyses for EH time of development on the crown would quantify these results (Hubbard, Guatelli-Steinberg & Sciulli, 2009). The affected individuals could then be further assessed as a sub-group to assess whether dental and other comorbidities were prevalent due to endured physiological insults during development.

Implementing radiographic imaging techniques would allow for precise pathology expression for caries, subsurface trauma, and infectious lesions. Caries were only recorded in this study when the enamel or cementum was extrinsically decayed, and differentiating between opaque hypoplastic markings on the surface between carious lesions or trauma is impossible to accurately conduct macroscopically. Furthermore, as reported in this study, infectious lesions represented lower incidence rates, in addition to conditions such as hypercementosis, which are often uncovered alongside infections (Corruccini et al., 1987; Zhou et al., 2012; d'Incau et al., 2015). Defining the accurate frequency of infectious lesions and their types (granuloma, cyst, abscess) with radiographic examination would be helpful to investigate similar objectives as suggested in this study, albeit with greater precision.

An interesting result of this study was temporal fluctuations in oral health. Although the assessment of temporal contexts has been conducted many times for sAHGH remains using a variety of research avenues (Deacon et al., 1978; Morris, 1992a; Sealy & Pfeiffer, 2000; Stock & Pfeiffer, 2004; Kusimba, 2005; Pfeiffer & Sealy, 2006; Sealy, 2006, 2010; Stynder, 2006; Pfeiffer, 2007; Pfeiffer & Harrington, 2011; Black, 2014; Irish et al., 2014; Pfeiffer et al., 2019; Gibbon & Davies, 2020), these findings demonstrated how subtle these improvements may be, where sAHGH health seemingly improved around the period when herding was introduced. Although this study did not determine between individual cases of a HGH lifeway through macroscopic assessment of the dentition, the findings demonstrated that changes brought upon by a new lifeway may reflect in the form of oral pathology frequency and hypoplastic defects. Macroscopically examining dental wear and oral health has often been conducted on contact period southern African remains through a site-specific approach (Morris, 1992a; Botha & Steyn, 2015, 2016); therefore, a similar systematic assessment on sAHGH individuals following the colonisation of southern Africa may provide additional insights into population-wide transitions.

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APPENDICES

Appendix A: Ethics approvals.

UNIVERSITY OF CAPE TOWN
Faculty of Health Sciences
Human Research Ethics Committee

Room G50- Old Main Building
Groote Schuur Hospital
Observatory 7925
Telephone [021] 406 6492
Email: hrec-enquiries@uct.ac.za
Website: www.health.uct.ac.za/fhs/research/humanethics/forms

16 February 2021

HREC REF: 791/2020

A/Prof V Gibbon
Division of Clinical Anatomy & Biological Anthropology
Level 5, Room 5.14 Anatomy Building-FHS
Email: Victoria.gibbon@uct.ac.za
Student: OLSJUD001@myuct.ac.za

Dear A/Prof Gibbon

PROJECT TITLE: DENTAL PATHOLOGY AND MACROWEAR: A BIOCULTURAL ANALYSIS OF SOUTHERN AFRICAN HOLOCENE HUNTER-GATHERERS AND HUNTER-HERDERS-DOCTORATE CANDIDATE-MS JUDYTA OLSZEWSKI

Thank you for submitting your study to the Faculty of Health Sciences Human Research Ethics Committee (HREC) for review.

It is a pleasure to inform you that the HREC has **formally approved** the above-mentioned study.

This approval is subject to strict adherence to the HREC recommendations regarding research involving human participants during COVID -19, dated 17 March 2020 & 06 July 2020.

Approval is granted for one year until the 28 February 2022.

Please submit a progress form, using the standardised Annual Report Form if the study continues beyond the approval period. Please submit a Standard Closure form if the study is completed within the approval period.
(Forms can be found on our website: www.health.uct.ac.za/fhs/research/humanethics/forms)

The HREC acknowledge that the student: Ms Judyta Olszewski will also be involved in this study.

Please quote the HREC REF 791/2020 in all your correspondence.

Yours sincerely

PROFESSOR M BLOCKMAN
CHAIRPERSON, FACULTY OF HEALTH SCIENCES HUMAN RESEARCH ETHICS COMMITTEE
Federal Wide Assurance Number: FWA00001637.
Institutional Review Board (IRB) number: IRB00001938
NHREC-registration number: REC-210208-007

This serves to confirm that the University of Cape Town Human Research Ethics Committee complies to the Ethics Standards for Clinical Research with a new drug in patients, based on the Medical Research Council (MRC-SA), Food and Drug Administration (FDA-USA), International Council for Harmonisation of Technical Requirements for Pharmaceuticals for Human Use: Good Clinical Practice (ICH GCP), South African Good Clinical Practice Guidelines (DoH 2006), based on the Association of the British Pharmaceutical Industry Guidelines (ABPI), and Declaration of Helsinki (2013) guidelines. The Human Research Ethics Committee granting this approval is in compliance with the ICH Harmonised Tripartite Guidelines E6: Note for Guidance on Good Clinical Practice (CPMP/ICH/135/95) and FDA Code Federal Regulation Part 50, 56 and 312.

Figure A1: Ethical clearances for this study granted by the Human Research Ethics Committee, University of Cape Town in 2021 (HREC REF: 791/2020). [Continues on next page.]

HUMAN RESEARCH
ETHICS COMMITTEE
18 FEB 2022
HEALTH SCIENCES FACULTY
UNIVERSITY OF CAPE TOWN

UNIVERSITY OF CAPE TOWN

FACULTY OF HEALTH SCIENCES
Human Research Ethics Committee

FHS016: Annual Progress Report / Renewal

HREC office use only (FWA00001637; IRB00001938)			
This serves as notification of annual approval, including any documentation described below.			
☑ Approved	Annual progress report	Approved until/next renewal date	28/02/23
☐ Not approved	See attached comments		
Signature Chairperson of the HREC/ Designee	[signature]	Date Signed	19/2/2022

Note: Please email this form and supporting documents (if applicable) in a combined pdf-file to hrec-enquiries@uct.ac.za.
Please clarify your plan for research-related activities during COVID-19 lockdown.
Please use the latest form found on our website:
http://www.health.uct.ac.za/fhs/research/humanethics/forms

Comments to PI from the HREC

Figure A1 (cont.): Ethical clearances for this study granted by the Human Research Ethics Committee, University of Cape Town in 2021 (HREC REF: 791/2020).

Appendix B: Sample information.

Table B1: Demographic and repository information about the sample from this study (*n* = 369). [Continues to page 281.]

Repository	Repository individual identification	Spatial	Pre-/Post-2000 BP	Holocene Divisions	Sex	Age estimate: 1=YA (18-34) 2= YA/MA 3= MA (35-49) 4= MA/OA 5= OA (50+a)
University of Cape Town Human Skeletal Repository	UCT 1	Inland	Post-2000	Later	Female	YA
	UCT 5	Inland	Unknown	Unknown	Female	Y/MA
	UCT 36	Inland	Post-2000	Later	Male	M/OA
	UCT 106	Inland	Pre-2000	Middle	Female	MA
	UCT 107	Coastal	Pre-2000	Middle	Male	M/OA
	UCT 113	Coastal	Pre-2000	Earlier	Female	M/OA
	UCT 120	Coastal	Post-2000	Later	Female	MA
	UCT 130	Inland	Post-2000	Later	Male	Y/MA
	UCT 162	Coastal	Pre-2000	Middle	Female	MA
	UCT 181/206	Coastal	Pre-2000	Earlier	Male	Y/MA
	UCT 182/200	Coastal	Pre-2000	Earlier	Female	Y/MA
	UCT 232	Coastal	Unknown	Unknown	Male	Y/MA
	UCT 250	Unknown	Unknown	Unknown	Male	MA
	UCT 254	Coastal	Post-2000	Later	Male	Y/MA
	UCT 318	Coastal	Post-2000	Later	Female	MA
	UCT 399	Coastal	Post-2000	Later	Female	OA
	UCT 578	Coastal	Pre-2000	Middle	Female	MA
	UCT 591	Coastal	Pre-2000	Middle	Male	Y/MA

UCT 676	Coastal	Post-2000	Later	Female	MA
UCT 683	Coastal	Post-2000	Later	Male	M/OA
UCT 226	Coastal	Post-2000	Later	Male	M/OA
UCT 579	Coastal	Post-2000	Later	Female	Y/MA
UCT 391	Coastal	Pre-2000	Middle	Female	Y/MA
UCT 192/213	Coastal	Pre-2000	Earlier	Female	Y/MA
UCT 246	Coastal	Pre-2000	Middle	Female	Y/MA
UCT 230	Coastal	Post-2000	Later	Male	Y/MA
UCT 67b	Coastal	Post-2000	Later	Male	MA
UCT 158	Coastal	Pre-2000	Middle	Female	MA
UCT 565	Inland	Post-2000	Later	Male	Y/MA
UCT 566	Inland	Pre-2000	Earlier	Female	Y/MA
UCT 183/201	Coastal	Pre-2000	Earlier	Female	Indeterminate
UCT 164	Coastal	Pre-2000	Middle	Female	MA
UCT 386	Coastal	Post-2000	Later	Male	Indeterminate
UCT 450	Coastal	Post-2000	Later	Male	Y/MA
UCT 172	Coastal	Pre-2000	Middle	Female	MA
UCT 661	Coastal	Pre-2000	Middle	Indeterminate	Indeterminate
UCT 428	Coastal	Post-2000	Later	Indeterminate	M/OA
UCT 331	Coastal	Pre-2000	Middle	Indeterminate	M/OA
UCT 323	Coastal	Pre-2000	Earlier	Female	M/OA
UCT 620	Coastal	Post-2000	Later	Female	Indeterminate
UCT 531	Coastal	Post-2000	Later	Female	Indeterminate
UCT 131	Inland	Post-2000	Later	Indeterminate	OA
UCT 587	Coastal	Pre-2000	Middle	Indeterminate	Indeterminate
UCT 60	Coastal	Post-2000	Later	Indeterminate	M/OA
UCT 539	Coastal	Post-2000	Later	Male	Indeterminate
UCT 584	Coastal	Pre-2000	Middle	Female	Indeterminate
UCT 609	Coastal	Pre-2000	Middle	Indeterminate	M/OA

UCT 427	Coastal	Pre-2000	Middle	Female	M/OA
UCT 383	Inland	Post-2000	Later	Male	M/OA
UCT 382	Inland	Post-2000	Later	Male	M/OA
UCT 372	Coastal	Pre-2000	Middle	Male	Indeterminate
UCT 168	Coastal	Post-2000	Later	Male	Indeterminate
UCT 169	Coastal	Pre-2000	Middle	Female	M/OA
UCT 248a	Coastal	Pre-2000	Earlier	Female	Indeterminate
UCT 347	Coastal	Pre-2000	Middle	Male	M/OA
UCT 332A	Coastal	Pre-2000	Middle	Male	Y/MA
UCT 2	Inland	Post-2000	Later	Female	Y/MA
UCT 66	Inland	Post-2000	Later	Male	Y/MA
UCT 88	Inland	Post-2000	Later	Female	Y/MA
UCT 112	Coastal	Pre-2000	Earlier	Male	M/OA
UCT 185/202	Coastal	Pre-2000	Earlier	Female	MA
UCT 392 + 387	Coastal	Pre-2000	Middle	Male	Y/MA
UCT 412	Inland	Post-2000	Later	Female	Y/MA
UCT 451	Coastal	Post-2000	Later	Female	Y/MA
UCT 593	Coastal	Post-2000	Later	Female	Y/MA
UCT 622	Coastal	Pre-2000	Middle	Male	Y/MA
UCT 686	Coastal	Unknown	Unknown	Male	M/OA
UCT 436	Coastal	Pre-2000	Middle	Female	Y/MA
UCT 10	Coastal	Unknown	Unknown	Male	M/OA
UCT 11	Unknown	Post-2000	Later	Female	Indeterminate
UCT 12	Unknown	Unknown	Unknown	Female	M/OA
UCT 14	Unknown	Unknown	Unknown	Indeterminate	Indeterminate
UCT 18	Coastal	Unknown	Unknown	Male	M/OA
UCT 55	Coastal	Post-2000	Later	Male	M/OA
UCT 62	Coastal	Post-2000	Later	Male	MA

UCT 67a	Coastal	Post-2000	Later	Male	M/OA
UCT 75	Coastal	Post-2000	Later	Female	Y/MA
UCT 78	Coastal	Pre-2000	Middle	Female	M/OA
UCT 83	Coastal	Post-2000	Later	Male	Y/MA
UCT 92	Inland	Post-2000	Later	Male	OA
UCT 109	Coastal	Post-2000	Later	Female	M/OA
UCT 114	Coastal	Post-2000	Later	Male	M/OA
UCT 134	Coastal	Pre-2000	Middle	Male	M/OA
UCT 148	Inland	Post-2000	Later	Male	M/OA
UCT 156	Coastal	Pre-2000	Earlier	Male	M/OA
UCT 157	Inland	Post-2000	Later	Male	M/OA
UCT 161	Coastal	Pre-2000	Middle	Female	MA
UCT 167	Coastal	Pre-2000	Middle	Female	OA
UCT 218b	Coastal	Pre-2000	Earlier	Indeterminate	Indeterminate
UCT 218d	Coastal	Pre-2000	Earlier	Indeterminate	Indeterminate
UCT 224	Coastal	Pre-2000	Middle	Female	YA
UCT 227	Inland	Post-2000	Later	Male	OA
UCT 229	Coastal	Pre-2000	Middle	Female	Indeterminate
UCT 243	Inland	Pre-2000	Earlier	Indeterminate	Indeterminate
UCT 262	Coastal	Post-2000	Later	Male	OA
UCT 272	Coastal	Unknown	Unknown	Female	M/OA
UCT 333	Inland	Pre-2000	Middle	Female	MA
UCT 343	Coastal	Pre-2000	Middle	Female	MA
UCT 389	Coastal	Pre-2000	Middle	Indeterminate	Indeterminate
UCT 421	Coastal	Pre-2000	Middle	Male	M/OA
UCT 429	Coastal	Post-2000	Later	Female	OA
UCT 435	Coastal	Pre-2000	Middle	Female	M/OA
UCT 445	Coastal	Pre-2000	Middle	Female	YA

	UCT 582	Coastal	Post-2000	Later	Female	Y/MA
	UCT 586	Coastal	Pre-2000	Middle	Female	MA
	UCT 596	Coastal	Pre-2000	Middle	Male	M/OA
	UCT 618	Coastal	Post-2000	Later	Female	YA
	UCT 652	Coastal	Unknown	Unknown	Indeterminate	OA
	UCT 56	Coastal	Post-2000	Later	Indeterminate	Indeterminate
	UCT 140	Coastal	Unknown	Unknown	Indeterminate	Indeterminate
	UCT 184/211	Coastal	Pre-2000	Earlier	Indeterminate	Indeterminate
	UCT 222	Coastal	Pre-2000	Middle	Male	Indeterminate
	UCT 242	Inland	Pre-2000	Earlier	Indeterminate	Indeterminate
	UCT 270	Coastal	Unknown	Unknown	Indeterminate	Indeterminate
	UCT 332 b =3	Coastal	Pre-2000	Middle	Indeterminate	Indeterminate
	UCT 345	Coastal	Pre-2000	Middle	Female	Indeterminate
	UCT 374	Coastal	Pre-2000	Earlier	Indeterminate	Indeterminate
	UCT 378	Coastal	Pre-2000	Earlier	Indeterminate	Indeterminate
	UCT 419	Coastal	Pre-2000	Middle	Indeterminate	Indeterminate
	UCT 600	Coastal	Post-2000	Later	Male	Y/MA
	UCT 663	Coastal	Unknown	Unknown	Indeterminate	Indeterminate
	UCT 664	Coastal	Post-2000	Later	Indeterminate	Indeterminate
	UCT 679	Coastal	Pre-2000	Middle	Indeterminate	Indeterminate
	UCT 680	Unknown	Unknown	Unknown	Indeterminate	Indeterminate
	UCT 687	Coastal	Unknown	Unknown	Indeterminate	M/OA
	UCT 31	Inland	Post-2000	Later	Male	MA
	UCT 43	Inland	Post-2000	Later	Female	MA
	UCT 44	Inland	Post-2000	Later	Male	Y/MA
	UCT 50	Inland	Post-2000	Later	Male	M/OA
	UCT 54	Inland	Post-2000	Later	Female	OA
	A32	Coastal	Unknown	Unknown	Male	M/OA

Raymond A. Dart Human Remains Collection, The University of the Witwatersrand	A34	Inland	Unknown	Unknown	Male	Y/MA
	A35	Inland	Unknown	Unknown	Male	Indeterminate
	A47	Inland	Unknown	Unknown	Male	M/OA
	A121	Inland	Post-2000	Later	Male	Indeterminate
	A125	Inland	Unknown	Unknown	Female	Indeterminate
	A180	Coastal	Unknown	Unknown	Male	M/OA
	A198	Inland	Unknown	Unknown	Male	Y/MA
	A233	Inland	Post-2000	Later	Male	Indeterminate
	A240	Inland	Unknown	Unknown	Female	Y/MA
	A268	Inland	Post-2000	Later	Male	M/OA
	A275	Inland	Unknown	Unknown	Male	Indeterminate
	A304	Inland	Unknown	Unknown	Indeterminate	Indeterminate
	A319	Inland	Unknown	Unknown	Male	Y/MA
	A320	Inland	Unknown	Unknown	Female	M/OA
	A330	Inland	Post-2000	Later	Male	M/OA
	A332	Inland	Post-2000	Later	Male	Indeterminate
	A333	Inland	Post-2000	Later	Male	Indeterminate
	A334	Inland	Post-2000	Later	Male	M/OA
	A411	Coastal	Unknown	Unknown	Male	M/OA
	A414	Inland	Post-2000	Later	Indeterminate	Indeterminate
	A914	Inland	Unknown	Unknown	Male	Indeterminate
	A1048	Inland	Unknown	Unknown	Female	Indeterminate
	A1112a	Coastal	Pre-2000	Middle	Male	Y/MA
	A1112b	Coastal	Pre-2000	Middle	Male	Indeterminate
	A1112c	Coastal	Pre-2000	Middle	Male	M/OA
	A1114	Coastal	Pre-2000	Middle	Male	M/OA
	A1115	Coastal	Pre-2000	Middle	Male	MA
	A1117	Coastal	Post-2000	Later	Female	Y/MA

	A1124	Coastal	Pre-2000	Earlier	Female	Indeterminate
	A1127	Coastal	Post-2000	Later	Female	M/OA
	A1139	Coastal	Pre-2000	Earlier	Male	M/OA
	A1152	Coastal	Post-2000	Later	Male	M/OA
	A1153	Inland	Post-2000	Later	Male	MA
	A1154	Inland	Post-2000	Later	Male	Y/MA
	A1166	Coastal	Post-2000	Later	Female	Y/MA
	A1172	Coastal	Pre-2000	Middle	Female	M/OA
	A1217	Coastal	Unknown	Unknown	Indeterminate	Indeterminate
	A1654	Coastal	Unknown	Unknown	Male	Indeterminate
	A2226	Coastal	Post-2000	Later	Male	M/OA
	A2227	Coastal	Post-2000	Later	Male	YA
National Museum, Bloemfontein	P1234	Coastal	Pre-2000	Earlier	Indeterminate	Indeterminate
	P1236a	Coastal	Pre-2000	Earlier	Indeterminate	Indeterminate
	P1236c	Coastal	Pre-2000	Earlier	Indeterminate	Indeterminate
	211? (2/2)	Coastal	Unknown	Unknown	Male	Indeterminate
	P8	Coastal	Pre-2000	Earlier	Indeterminate	Indeterminate
	P6	Coastal	Pre-2000	Earlier	Indeterminate	Indeterminate
	P1275	Coastal	Pre-2000	Earlier	Male	Y/MA
	P1277	Coastal	Pre-2000	Earlier	Female	Indeterminate
	P1278	Coastal	Pre-2000	Earlier	Male	Indeterminate
	P1273	Coastal	Pre-2000	Middle	Male	Y/MA
	P1274	Coastal	Pre-2000	Earlier	Female	Indeterminate
	P1263	Coastal	Unknown	Unknown	Indeterminate	Indeterminate
	P1264	Coastal	Pre-2000	Earlier	Male	Indeterminate
	P1265	Coastal	Pre-2000	Earlier	Male	Indeterminate
	P1247	Coastal	Pre-2000	Middle	Female	Indeterminate
	P1249	Coastal	Pre-2000	Middle	Male	Indeterminate

	P1250	Coastal	Pre-2000	Middle	Indeterminate	Indeterminate
	P1251	Coastal	Unknown	Unknown	Female	Indeterminate
	P1241	Coastal	Pre-2000	Middle	Female	Indeterminate
	P1243a	Coastal	Pre-2000	Middle	Indeterminate	Indeterminate
	P1243b	Coastal	Pre-2000	Middle	Indeterminate	Indeterminate
	P1244	Coastal	Pre-2000	Middle	Indeterminate	Indeterminate
	P1440	Coastal	Pre-2000	Middle	Female	Indeterminate
	P1441	Coastal	Pre-2000	Earlier	Female	Indeterminate
	P1443	Coastal	Pre-2000	Earlier	Female	Indeterminate
	P1442	Coastal	Pre-2000	Earlier	Indeterminate	Indeterminate
	P1445	Coastal	Pre-2000	Earlier	Indeterminate	Indeterminate
	P1446	Coastal	Pre-2000	Earlier	Indeterminate	Indeterminate
	P1438	Coastal	Unknown	Unknown	Indeterminate	Indeterminate
	P1308	Coastal	Pre-2000	Earlier	Indeterminate	Indeterminate
	P1310	Coastal	Pre-2000	Earlier	Indeterminate	Indeterminate
	P1373	Coastal	Pre-2000	Earlier	Indeterminate	Indeterminate
	P1286	Coastal	Unknown	Unknown	Male	Indeterminate
	P1298	Coastal	Unknown	Unknown	Male	Indeterminate
	P1282	Coastal	Pre-2000	Earlier	Female	Indeterminate
	P1602	Coastal	Pre-2000	Earlier	Indeterminate	Indeterminate
	P1448a	Coastal	Pre-2000	Earlier	Male	Indeterminate
	P1448b	Coastal	Unknown	Unknown	Indeterminate	Indeterminate
	P1447	Coastal	Unknown	Unknown	Male	Indeterminate
	MSK3	Coastal	Pre-2000	Middle	Indeterminate	Indeterminate
	M_MRC_SSI_4	Coastal	Unknown	Unknown	Male	Indeterminate
KwaZulu Natal Museum	2009/006	Coastal	Post-2000	Later	Indeterminate	M/OA
	1991/054.002	Coastal	Pre-2000	Middle	Male	Indeterminate
	2009/8	Coastal	Pre-2000	Middle	Male	M/OA

	2009/8.002	Coastal	Pre-2000	Middle	Male	Indeterminate
	2009/009	Coastal	Pre-2000	Earlier	Indeterminate	Indeterminate
	2009/010	Coastal	Pre-2000	Middle	Indeterminate	M/OA
University of Cape Town Unaccessioned: (AR#) from Archaeology Department: *Unaccessioned, permission through Prof. Sealy (26/3/2021).* (Heritage Western Cape#) from Forensic Anthropology Cape Town Lab: *Unaccessioned, Heritage Western Cape cases.*	UCT unaccessioned individual (HWC1)	Coastal	Unknown	Unknown	Female	MA
	UCT unaccessioned individual (HWC2)	Coastal	Unknown	Unknown	Indeterminate	Indeterminate
	UCT unaccessioned individual (AR1)	Coastal	Pre-2000	Middle	Male	MA
	UCT unaccessioned individual (AR2)	Coastal	Pre-2000	Middle	Female	MA
	UCT unaccessioned individual (AR3)	Coastal	Pre-2000	Middle	Male	MA
	UCT unaccessioned individual (AR4)	Coastal	Pre-2000	Middle	Male	Y/MA
	UCT unaccessioned individual (AR5)	Coastal	Post-2000	Later	Female	Y/MA
	UCT unaccessioned individual (AR6)	Coastal	Post-2000	Later	Male	Y/MA
	UCT unaccessioned individual (AR7)	Coastal	Post-2000	Later	Indeterminate	Indeterminate
	UCT unaccessioned individual (AR8)	Coastal	Pre-2000	Middle	Male	YA
	UCT unaccessioned individual (AR9)	Unknown	Pre-2000	Middle	Female	Indeterminate
	UCT unaccessioned individual (AR10)	Coastal	Pre-2000	Middle	Indeterminate	Y/MA

	UCT unaccessioned individual (AR11)	Coastal	Unknown	Unknown	Indeterminate	MA
	UCT unaccessioned individual (AR12)	Coastal	Post-2000	Later	Male	Y/MA
	UCT unaccessioned individual (AR13)	Coastal	Unknown	Unknown	Female	Y/MA
Iziko Museums	SAM-AP 1473	Coastal	Post-2000	Later	Female	Y/MA
	SAM-AP 32	Coastal	Pre-2000	Middle	Female	Y/MA
	SAM-AP 1863	Coastal	Post-2000	Later	Indeterminate	Indeterminate
	SAM-AP 1457	Coastal	Post-2000	Later	Female	Y/MA
	SAM-AP 34	Coastal	Pre-2000	Middle	Male	M/OA
	SAM-AP 1145	Coastal	Pre-2000	Middle	Male	Indeterminate
	SAM-AP 1441	Coastal	Pre-2000	Middle	Male	Indeterminate
	SAM-AP 1247a	Coastal	Post-2000	Later	Female	Y/MA
	SAM-AP 37	Coastal	Pre-2000	Earlier	Indeterminate	Indeterminate
	SAM-AP 1446	Coastal	Post-2000	Later	Female	MA
	SAM-AP 3737	Coastal	Post-2000	Later	Indeterminate	Indeterminate
	SAM-AP 1157	Coastal	Pre-2000	Middle	Female	Y/MA
	SAM-AP 3053	Coastal	Post-2000	Later	Male	Indeterminate
	SAM-AP 1878a	Coastal	Pre-2000	Middle	Male	MA
	SAM-AP 1443	Coastal	Pre-2000	Middle	Male	MA
	SAM-AP 1146	Coastal	Pre-2000	Middle	Male	MA
	SAM-AP 3026a	Coastal	Pre-2000	Middle	Female	YA
	SAM-AP 4202	Coastal	Pre-2000	Middle	Female	Indeterminate
	SAM-AP 4210	Coastal	Pre-2000	Middle	Female	Indeterminate
	SAM-AP 39	Coastal	Pre-2000	Middle	Female	Indeterminate
	SAM-AP 1449	Coastal	Pre-2000	Middle	Indeterminate	Y/MA
	SAM-AP 4906b	Coastal	Pre-2000	Middle	Male	Indeterminate

	SAM-AP 4728a	Coastal	Pre-2000	Earlier	Male	Indeterminate
	SAM-AP 1128	Coastal	Pre-2000	Middle	Female	Indeterminate
	SAM-AP 4204	Coastal	Unknown	Unknown	Female	Indeterminate
	SAM-AP 4308	Coastal	Pre-2000	Middle	Indeterminate	Indeterminate
	SAM-AP 4790	Coastal	Post-2000	Later	Male	MA
	SAM-AP 4312	Coastal	Pre-2000	Middle	Female	Indeterminate
	SAM-AP 4306	Coastal	Pre-2000	Middle	Indeterminate	Indeterminate
	SAM-AP 4636	Coastal	Pre-2000	Middle	Male	Indeterminate
	SAM-AP 4800	Coastal	Pre-2000	Middle	Female	MA
	SAM-AP 4813	Coastal	Pre-2000	Middle	Female	Indeterminate
	SAM-AP 4825	Coastal	Pre-2000	Middle	Male	Indeterminate
	SAM-AP 4734	Coastal	Pre-2000	Earlier	Female	Indeterminate
	SAM-AP 4899	Coastal	Pre-2000	Middle	Male	Indeterminate
	SAM-AP 4905	Coastal	Post-2000	Later	Male	Y/MA
	SAM-AP 4793	Coastal	Pre-2000	Middle	Male	Indeterminate
	SAM-AP 5048	Coastal	Pre-2000	Middle	Female	YA
	SAM-AP 4935	Coastal	Pre-2000	Middle	Indeterminate	Indeterminate
	SAM-AP 4942	Coastal	Pre-2000	Middle	Male	Indeterminate
	SAM-AP 4964	Coastal	Pre-2000	Middle	Male	Y/MA
	SAM-AP 1893	Coastal	Pre-2000	Middle	Male	MA
	SAM-AP 5040	Coastal	Pre-2000	Middle	Female	Indeterminate
	SAM-AP 5049	Coastal	Pre-2000	Middle	Female	Indeterminate
	SAM-AP 1879	Coastal	Pre-2000	Middle	Male	Y/MA
	SAM-AP 5050	Coastal	Pre-2000	Middle	Female	MA
	SAM-AP 4828	Coastal	Pre-2000	Earlier	Indeterminate	Indeterminate
	SAM-AP 1871	Coastal	Pre-2000	Middle	Female	MA
	SAM-AP 5036	Coastal	Post-2000	Later	Male	Y/MA

	SAM-AP 6041b	Coastal	Pre-2000	Middle	Male	Y/MA
	SAM-AP 6041a	Coastal	Post-2000	Later	Male	Y/MA
	SAM-AP 6051	Coastal	Pre-2000	Middle	Female	Y/MA
	SAM-AP 5077 (4)	Coastal	Pre-2000	Middle	Male	MA
	SAM-AP 6043	Coastal	Pre-2000	Middle	Male	Indeterminate
	SAM-AP 5034	Coastal	Post-2000	Later	Male	Indeterminate
	SAM-AP 6050	Coastal	Post-2000	Later	Female	Indeterminate
	SAM-AP 5095	Coastal	Pre-2000	Middle	Female	Y/MA
	SAM-AP 5083	Coastal	Post-2000	Later	Female	M/OA
	SAM-AP 5068	Coastal	Pre-2000	Earlier	Indeterminate	Indeterminate
	SAM-AP 5073	Coastal	Post-2000	Later	Female	Indeterminate
	SAM-AP 5082	Coastal	Pre-2000	Middle	Male	Indeterminate
	SAM-AP 5075	Coastal	Pre-2000	Middle	Male	Y/MA
	SAM-AP 5091	Coastal	Pre-2000	Middle	Indeterminate	Indeterminate
	SAM-AP 5041	Coastal	Pre-2000	Middle	Male	Y/MA
	SAM-AP 6031	Coastal	Pre-2000	Middle	Male	Indeterminate
	SAM-AP 6032	Coastal	Pre-2000	Earlier	Indeterminate	Indeterminate
	SAM-AP 6272	Coastal	Pre-2000	Earlier	Male	Indeterminate
	SAM-AP 6318	Coastal	Pre-2000	Middle	Male	Y/MA
	SAM-AP 6020	Coastal	Post-2000	Later	Male	Y/MA
	SAM-AP 6348b	Coastal	Unknown	Unknown	Female	M/OA
	SAM-AP 6149	Coastal	Post-2000	Later	Male	MA
	SAM-AP 6317	Coastal	Pre-2000	Middle	Male	MA
	SAM-AP 6022	Coastal	Post-2000	Later	Male	Indeterminate
	SAM-AP 6334	Coastal	Post-2000	Later	Female	Indeterminate
	SAM-AP 6147	Coastal	Pre-2000	Middle	Male	Y/MA
	SAM-AP 6264	Coastal	Post-2000	Later	Male	Y/MA

	SAM-AP 6332	Coastal	Post-2000	Later	Male	Indeterminate
	SAM-AP 6075	Coastal	Post-2000	Later	Female	Y/MA
	SAM-AP 6260a	Coastal	Pre-2000	Middle	Female	M/OA
	SAM-AP 6074	Coastal	Post-2000	Later	Male	YA
	SAM-AP 6071	Coastal	Post-2000	Later	Male	Indeterminate
	SAM-AP 5035d	Coastal	Post-2000	Later	Male	Indeterminate
	SAM-AP 6331	Coastal	Post-2000	Later	Female	Y/MA
	SAM-AP 4931	Inland	Pre-2000	Middle	Male	Y/MA
	SAM-AP 6319	Coastal	Pre-2000	Middle	Female	Indeterminate
	SAM-AP 5035a	Coastal	Post-2000	Later	Male	Y/MA
	SAM-AP 4713	Coastal	Pre-2000	Middle	Indeterminate	Indeterminate
	SAM-AP 4720	Coastal	Pre-2000	Middle	Male	Y/MA
	SAM-AP 4930	Coastal	Post-2000	Later	Female	MA
	SAM-AP 6313a	Coastal	Pre-2000	Middle	Female	Indeterminate
	SAM-AP 6313b	Coastal	Pre-2000	Middle	Female	Indeterminate
	SAM-AP 4296	Coastal	Unknown	Unknown	Indeterminate	Indeterminate
	SAM-AP 4791	Coastal	Unknown	Unknown	Indeterminate	Indeterminate
	SAM-AP 4293	Coastal	Unknown	Unknown	Indeterminate	Indeterminate
	SAM-AP 4711/12	Coastal	Unknown	Unknown	Indeterminate	Indeterminate
	SAM-AP 4739	Coastal	Unknown	Unknown	Indeterminate	Indeterminate
	SAM-AP 4714/15	Coastal	Unknown	Unknown	Indeterminate	Indeterminate
	SAM-AP 4721	Coastal	Unknown	Unknown	Indeterminate	Indeterminate
	SAM-AP 4933	Coastal	Unknown	Unknown	Female	Indeterminate
	SAM-AP 4840	Coastal	Unknown	Unknown	Female	YA
	SAM-AP 6072	Coastal	Unknown	Unknown	Male	YA
	SAM-AP 6049	Coastal	Unknown	Unknown	Male	MA
	SAM-AP 5084	Coastal	Unknown	Unknown	Indeterminate	Indeterminate

	SAM-AP 4838	Coastal	Unknown	Unknown	Indeterminate	Indeterminate
	SAM-AP 4314	Coastal	Post-2000	Later	Female	Indeterminate
	SAM-AP 1260	Coastal	Post-2000	Later	Male	Indeterminate
	SAM-AP 4180	Coastal	Post-2000	Later	Female	Indeterminate
	SAM-AP 4713a	Coastal	Pre-2000	Middle	Indeterminate	Indeterminate
	SAM-AP 4179	Coastal	Unknown	Unknown	Female	Indeterminate
	SAM-AP 36	Coastal	Unknown	Unknown	Indeterminate	Indeterminate
	SAM-AP 278g	Coastal	Pre-2000	Middle	Male	Indeterminate
	SAM-AP 1894	Coastal	Pre-2000	Middle	Indeterminate	Indeterminate
	SAM-AP 1162	Coastal	Unknown	Unknown	Indeterminate	Indeterminate
	SAM-AP 4302	Coastal	Pre-2000	Middle	Female	Indeterminate
	SAM-AP 4300	Coastal	Pre-2000	Middle	Female	Indeterminate
	SAM-AP 1142	Coastal	Pre-2000	Middle	Female	Indeterminate
	SAM-AP 320g	Coastal	Post-2000	Later	Female	Indeterminate
	SAM-AP 4794	Coastal	Unknown	Unknown	Female	Indeterminate
	SAM-AP 5054	Coastal	Unknown	Unknown	Male	Indeterminate
	SAM-AP 4974	Coastal	Pre-2000	Middle	Male	Indeterminate
	SAM-AP 4874	Coastal	Post-2000	Later	Female	Indeterminate
	SAM-AP 5035b	Coastal	Unknown	Unknown	Male	Indeterminate
	SAM-AP 4632	Coastal	Pre-2000	Middle	Indeterminate	Indeterminate
	SAM-AP 4627	Coastal	Pre-2000	Middle	Female	Indeterminate
	SAM-AP 4659	Coastal	Post-2000	Later	Female	Indeterminate
	SAM-AP 4898	Coastal	Post-2000	Later	Male	Indeterminate
	SAM-AP 4301	Coastal	Pre-2000	Middle	Female	Indeterminate
	SAM-AP 4299	Coastal	Pre-2000	Middle	Female	Indeterminate
	SAM-AP 6212	Coastal	Unknown	Unknown	Male	Indeterminate
	SAM-AP 6016	Coastal	Pre-2000	Middle	Indeterminate	Indeterminate

	SAM-AP 6213	Coastal	Post-2000	Later	Male	Indeterminate
	SAM-AP 6211	Coastal	Unknown	Unknown	Indeterminate	Indeterminate
	SAM-AP 5069	Coastal	Pre-2000	Middle	Female	Indeterminate
	SAM-AP 5070	Coastal	Pre-2000	Middle	Female	Indeterminate
	SAM-AP 4630	Coastal	Post-2000	Later	Female	Indeterminate
	SAM-AP 4901	Coastal	Post-2000	Later	Male	M/OA

Table B2: Heatmap of spatial and temporal information for cross-tabulated data, as affiliated with Figure 3.1. Archaeological sites are grouped into general provenances of nearest contemporary regions. [Continues to page 284.]

General Provenance	General Regional Coordinates	Pre-2000	Post-2000	Unknown
Amsterdam Hoek	-33.8520,25.6131		1	
Atlantis	-33.5063,18.4870			1
Augrabies Falls	-28.5942,20.3381		2	
Ballito Bay	-29.5237,31.2229	3		
Bonteheuwel	-33.9523,18.5528		1	
Blaauwkrantz	-28.8500,29.8500			1
Bloubergstrand	-33.8194,18.4866	4	3	1
Bokbaai	-33.342,18.197	1		
Brakfontein, Riversdale	-34.0317,21.2487			1
Bredasdorp	-34.5385,20.0569	1	1	1
Canon Island, Upington	-28.6552,21.0847		2	
Cape Agulhas	-34.8311,20.0131		1	
Cape Point	-34.3567,18.4968	1	1	
Cape St Francis	-34.2062,24.8300	1	3	
Clanwilliam	-32.1976,18.8967	2	1	
Darling	-33.3756,18.3861	8		
Die Duin	-33.9965,22.5943	2		
Doonside	-30.0732,30.8686	1		
Doornport/Jackalspits	-28.2845,24.4021		1	
Doringbaai	-31.8211,18.2392	1		
Eagles Nest, Modder River	-29.0261,24.6361			1
Eerstelling	-27.4480,31.0736			2
Elands Bay	-32.3135,18.3505	6	2	
Faraoskop	-32.3358,18.8097	3	1	
Fish Hoek	-34.1341,18.4187			3
Fynnlands	-29.9019,31.0263		1	
Gansbaai	-34.5805,19.3518	1	1	1
George	-33.9881,22.4530	2		2
Gordons Bay	-34.1515,18.8730	2		
Graaffrienet	-32.2547,24.5480			1
Great Brak	-34.0483,22.2205	1		1
Green point	-33.9070,18.4064		1	
Groenrivier	-33.3462,18.8650	1		
Groot Bakka, Kenhardt	-29.3541,21.2130		1	
Groot Hagel	-34.6649,19.5792		1	
Headlands	-18.2822,32.0527	1		
Heilbron	-27.2820,27.9835		1	
Hermanus	-34.4092,19.2504		2	
Hout Bay	-34.0209,18.3683	3	3	1
Humansdorp	-34.0027,24.7440	6	2	6
Jacobsbaai	-32.9690,17.8910	1		
Jacobsdal	-29.1333,24.7974		4	

Jeffreys Bay	-34.0507,24.9102		1	
Karbonkelberg	-34.0358,18.3208		1	
Kenkelbosch	-25.0333,27.6833	1		
Keurbooms	-34.0657,23.2481			1
Kleinsee, Namaqualand	-29.6783,17.0687	1		
Kleinzee	-29.6783,17.0687	2		
Klipfonteinrand	-32.40,19.90	1		
Knysna	-34.0351,23.0465	5		
Koffiefontein	-29.3860,24.9902			1
Koingnaas	-30.1962,17.2881		1	
Kommetjie	-34.1403,18.3292	3		
Kuilsriver	-33.9227,18.6898		1	1
Ladibrand	-29.1860,27.4439	1		
Ladismith	-33.4878,21.2785		2	
Langebaan	-33.0547,18.0658	4		
Langklip	-28.2114,20.3344	2		
Leeuwdoornstad	-27.2260,26.2482			1
Leeuwfontein	-25.1762,28.9022		1	
Lesotho	-29.6100,28.2336	1		
Little Brak	-34.0862,22.1460	1	2	
Llandudno	-34.0100,18.3430	2		
Loerie	-33.8760,25.0206		1	
Longlands, Vaal River	-28.4611,24.3609			1
Mount Hora, Malawi	-11.6600,33.6408	2		
Matjies river	-32.5001,19.3362	32		9
Matjeskloof	-31.1231,21.0708		1	
Melkbos	-33.7193,18.4543	13	13	2
Milnerton	-33.8660,18.5344	1	2	
Montagu	-33.7749,20.1224			1
Mossel Bay	-34.1747,22.0834	1	2	1
Nabookspruit	-24.5165,28.7174			1
Noetzie	-34.0782,23.1267	2		
Noordhoek	-34.0948,18.3950	8	1	
Oakhurst	-33.9354,22.6532	8	1	
Onrus	-34.4155,19.1791		1	
Oudtshoorn	-33.6007,22.2026		1	
Paarden Island	-33.9160,18.4721		1	
Paternoster	-32.8115,17.8954	1	1	
Pearly Beach	-34.6580,19.4884		2	
Plettenberg Bay	-34.0575,23.3645	4	3	1
Port Elizabeth	-33.9608,25.6022	2	2	
Port Nolloth	-29.2415,16.9004		2	
Quoin point	-34.7706,19.6580	1		
Renoster river	-27.6541,28.1355			1
Richmond, North Cape	-31.3645,23.9180		1	
Richtersveld	-28.6211,17.2430		1	1
Robberg	-34.1047,23.3953	13		1
Robberg	-34.1047,23.3953	2	1	

Saldanha	-33.0277,17.9176	6	4	2
Schweizer-Reneke	-27.1778,25.2956			1
Sedgefield	-34.0226,22.8076		2	2
Simonstown	-34.1938,18.4357	1		
Somerset	-32.7248,25.5800	1	1	
St Helena Bay	-32.7505,18.0036	1	1	
Steytlerville	-33.3136,24.2985		2	
Still Bay	-34.3642,21.4336	1		
Stompneus Bay	-32.7333,17.9667	2		2
Sutherland	-32.4101,20.6705		5	
Taung	-27.5518,24.7662		1	
Transkei	-31.3591,28.4823		2	1
Transvaal	-23.3166,30.5333		1	
Tsitsikamma	-34.0196,23.8936	3		
Vegkop	-27.4833,27.9000		1	
Velddrif	-32.7681,18.1607	1		
Vleesbaai	-34.2931,21.9142	1		
Vredenburg	-32.9128,17.9947		1	1
Waterloo Bay	-33.4761,27.1626			1
Watterbakke	-31.5532,18.3475		1	
Wilderness	-33.9940,22.5748		2	
Whitchers Cave	-33.9182,23.7811	1		
Yzerfontein	-33.3599,18.1592	2	1	3
Coastal	*Unknown*	1	5	5
Unknown	*Unknown*		1	4
Totals		**187**	**114**	**68**

Appendix C: Supplementary tables.

Table C1: Sample distribution for individuals with sex estimates from past studies due to an absence of scorable elements when accessed during data collection in 2021. Additional totals are presented to account for the remaining number of individuals with a sex estimate from the entire sample (*n* = 369).

Reference†	**n**	**%**
Black (2014)	3	4
Campbell (2019)	6	8
L'Abbé and colleagues (2008)	20	27
Hausman (1980)	22	30
Pfeiffer & Sealy (2006)	11	15
Sealy (2010)	2	3
Stynder and colleagues (2007)	9	12
Total referenced sex from literature	**73**	**20**
Total individuals assessed for sex‡	**211**	**57**
Total unobservable/indeterminate	**85**	**23**
Total individuals	**369**	**100**

n = sample size; †Percentages for individuals with sex from the literature were calculated against the total referenced sex (*n* = 73); ‡The total number of individuals assessed for sex in-lab using sex estimation methods.

Table C2: Sample distribution exhibiting number of individuals cross-tabulated for sex, spatial regions and temporal divisions (pre/post-2000 BP and Holocene divisions). Chi-squared tests were run and highlighted sampling biases for inland groups.

		Pre/post-2000 BP				Holocene divisions				
Spatial	**Sex**	**Pre-2000**	**Post-2000**	**Unknown**	***Totals***	**Earlier Holocene**	**Middle Holocene**	**Later Holocene**	**Unknown**	***Totals***
		n	***n***	***n***	***n***	***n***	***n***	***n***	***n***	***n***
Coastal	**Female**	68	35	10	*113*	14	54	35	10	*113*
	Male	64	39	19	*122*	11	53	39	19	*122*
	Indeterminate	47	8	23	*78*	22	25	8	23	*78*
Total coastal		179	82	52	*313*	47	132	82	52	*313*
Inland	**Female**	4	6	5	*15*	1	3	6	5	*15*
	Male	1	22	7	*30*	0	1	22	7	*30*
	Indeterminate	2	2	1	*5*	2	0	2	1	*5*
Total inland		7	30	13	*50*	3	4	30	13	*50*
Unknown	**Female**	1	1	1	*3*	0	1	1	1	*3*
	Male	0	0	1	*1*	0	0	0	1	*1*
	Indeterminate	0	0	2	*2*	0	0	0	2	*2*
Total unknown		1	1	4	*6*	0	1	1	4	*6*
	Totals	***187***	***113***	***69***	***369***	***50***	***137***	***113***	***69***	***369***

n = sample size

A Chi-Square Test of Independence was performed to assess the relationship between sex and pre/post-2000 BP within coastal spatial group. There was not a significant relationship between the two variables, $\chi2(1, 239) = .33$, $p = .561$.

A Chi-Square Test of Independence was performed to assess the relationship between sex and pre/post-2000 BP within inland spatial group. There was a significant relationship between the two variables, $\chi2(1, 239) = 6.89$, $p = .009$.

A Chi-Square Test of Independence was performed to assess the relationship between sex and Holocene divisions within coastal spatial group. There was not a significant relationship between the two variables, $\chi2(1, 239) = .58$, $p = .746$.

A Chi-Square Test of Independence was performed to assess the relationship between sex and Holocene divisions within inland spatial group. There was a significant relationship between the two variables, $\chi2(1, 239) = 7.12$, $p = .028$.

Table C3: Sample distribution exhibiting number of individuals cross-tabulated for age, spatial regions and temporal divisions (pre/post-2000 BP and Holocene divisions). Chi-squared tests were run and highlighted sampling biases for age categories when combined with other variables.

		Pre/Post-2000 BP				Holocene divisions				
Spatial	**Age estimate (adult groups)**	**Pre-2000**	**Post-2000**	**Unknown**	***Total***	**Earlier Holocene**	**Middle Holocene**	**Later Holocene**	**Unknown**	***Total***
		n	***n***	***n***	***n***	***n***	***n***	***n***	***n***	***n***
Coastal	**Young**	5	3	2	*10*	0	5	3	2	*10*
	Young/middle	28	26	2	*56*	4	24	26	2	*56*
	Middle	22	9	3	*34*	1	21	9	3	*34*
	Middle/old	23	13	10	*46*	5	18	13	10	*46*
	Old	1	3	1	*5*	0	1	3	1	*5*
	Indeterminate	100	28	34	*162*	37	63	28	34	*162*
Total coastal		179	82	52	*313*	47	132	82	52	*313*
Inland	**Young**	0	1	0	*1*	0	0	1	0	*1*
	Young/middle	2	8	5	*15*	1	1	8	5	*15*
	Middle	2	3	0	*5*	0	2	3	0	*5*
	Middle/old	0	9	2	*11*	0	0	9	2	*11*
	Old	0	4	0	*4*	0	0	4	0	*4*
	Indeterminate	3	5	6	*14*	2	1	5	6	*14*
Total inland		7	30	13	*50*	3	4	30	13	*50*
Unknown	**Young**	0	0	0	*0*	0	0	0	0	*0*
	Young/middle	0	0	0	*0*	0	0	0	0	*0*
	Middle	0	0	1	*1*	0	0	0	1	*1*
	Middle/old	0	0	1	*1*	0	0	0	1	*1*
	Old	0	0	0	*0*	0	0	0	0	*0*
	Indeterminate	1	1	2	*4*	0	1	1	2	*4*
Total unknown		1	1	4	*6*	0	1	1	4	*6*
Total		***187***	***113***	***69***	***369***	***50***	***137***	***113***	***69***	***369***

n = sample size; Age against pre/post-2000 BP in coastal groups or inland groups was not statistically significant p = .26 and p =.31, respectively according to a 2-sided Fishers exact test. Age against Holocene divisions in coastal groups or inland groups was not statistically significant because p = .37 and p = .37, respectively, according to a 2-sided Fishers exact test.

Table C4: Sample distribution for individuals and tooth counts against demographic variables assessed for this study. Teeth are categorised into morphological tooth groups. [Continues on next page.]

Demographic group	Demographic variable		Total Indiv-iduals	Dental expression and tooth group: Present					Antemortem tooth loss					Postmortem tooth loss/Absent				
				I	C	PM	M	*Total*	I	C	PM	M	*Total*	I	C	PM	M	*Total*
Sex estimate	Female	n	131	435	282	588	977	2282	8	2	17	68	95	605	240	443	527	1815
		%	36	19	12	26	43	36	8	2	18	72	46	33	13	24	29	34
	Male	n	153	526	358	720	1217	2821	5	2	6	63	76	693	252	498	556	1999
		%	41	19	13	26	43	45	7	3	8	83	37	35	13	25	28	38
	Indeterminate	n	85	231	168	314	455	1168	2	0	5	30	37	447	172	361	535	1515
		%	23	20	14	27	39	19	5	0	14	81	18	30	11	24	35	28
	Total	n	369	1192	808	1622	2649	6271	15	4	28	161	208	1745	664	1302	1618	5329
		%	100	19	13	26	42	100	7	2	13	77	100	33	12	24	30	100
Age estimate (adult groups)	Young	n	11	31	24	48	102	205	0	1	0	1	2	57	19	40	29	145
		%	3	15	12	23	50	3	0	50	0	50	1	39	13	28	20	3
	Young/ Middle	n	71	249	174	366	619	1408	0	1	5	28	34	319	109	197	205	830
		%	19	18	12	26	44	22	0	3	15	82	16	38	13	24	25	16
	Middle	n	40	133	89	191	309	722	9	2	3	17	31	178	69	126	154	527
		%	11	18	12	26	43	12	29	6	10	55	15	34	13	24	29	10
	Middle/ Old	n	58	163	124	228	433	948	0	0	7	30	37	301	108	229	233	871
		%	16	17	13	24	46	15	0	0	19	81	18	35	12	26	27	16
	Old	n	9	30	14	41	57	142	1	0	0	8	9	41	22	31	43	137
		%	2	21	10	29	40	2	11	0	0	89	4	30	16	23	31	3
	Indeterminate	n	180	586	383	748	1129	2846	5	0	13	77	95	849	337	679	954	2819
		%	49	21	13	26	40	45	5	0	14	81	46	30	12	24	34	53
	Total	n	369	1192	808	1622	2649	6271	15	4	28	161	208	1745	664	1302	1618	5329
		%	100	19	13	26	42	100	7	2	13	77	100	33	12	24	30	100

Spatial	Coastal	n	313	1052	697	1401	2221	5371	15	4	24	149	192	1437	551	1079	1386	4453
		%	85	20	13	26	41	86	8	2	13	78	92	32	12	24	31	84
	Inland	n	50	128	101	203	397	829	0	0	1	10	11	272	99	196	193	760
		%	14	15	12	24	48	13	0	0	9	91	5	36	13	26	25	14
	Unknown	n	6	12	10	18	31	71	0	0	3	2	5	36	14	27	39	116
		%	2	17	14	25	44	1	0	0	60	40	2	31	12	23	34	2
	Total	n	369	1192	808	1622	2649	6271	15	4	28	161	208	1745	664	1302	1618	5329
		%	100	19	13	26	42	100	7	2	13	77	100	33	12	24	30	100
Pre/Post-2000 BP	Pre-2000	n	186	604	405	812	1270	3091	10	1	17	90	118	882	342	667	884	2775
		%	50	20	13	26	41	49	8	1	14	76	57	32	12	24	32	52
	Post-2000	n	113	375	264	526	921	2086	3	3	3	36	45	526	185	375	399	1485
		%	31	18	13	25	44	33	7	7	7	80	22	35	12	25	27	28
	Unknown	n	70	213	139	284	458	1094	2	0	8	35	45	337	137	260	335	1069
		%	19	19	13	26	42	18	4	0	18	78	22	32	13	24	31	20
	Total	n	369	1192	808	1622	2649	6271	15	4	28	161	208	1745	664	1302	1618	5329
		%	100	19	13	26	42	100	7	2	13	77	100	33	12	24	30	100
Holocene divisions	Earlier	n	50	149	101	196	289	735	4	0	3	34	41	247	99	201	277	824
		%	14	20	14	27	39	12	10	0	7	83	20	30	12	24	34	15
	Middle	n	137	455	304	616	981	2356	6	1	14	56	77	635	243	466	607	1951
		%	37	19	13	26	42	38	8	1	18	73	37	33	12	24	31	37
	Later	n	113	375	264	526	921	2086	3	3	3	36	45	526	185	375	399	1485
		%	31	18	13	25	44	33	7	7	7	80	22	35	12	25	27	28
	Unknown	n	69	213	139	284	458	1094	2	0	8	35	45	337	137	260	335	1069
		%	19	19	13	26	42	17	4	0	18	78	22	32	13	24	31	20
	Total	n	369	1192	808	1622	2649	6271	15	4	28	161	208	1745	664	1302	1618	5329
		%	100	19	13	26	42	100	7	2	13	77	100	33	12	24	30	100

I = Incisors; C = Canines; PM = Premolars; M = Molars; *n* = sample size