Impact of urbanisation on population’s health in Mtskheta region – Georgia, from Late Bronze Age to Early Middle Ages

A thesis submitted by

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Abstract

The emergence of urbanisation is considered to be an important period in human history as it is associated with an increase in population density, diversification of subsistence activities, and the establishment of ancient cities, often with poor sanitation. Each of these factors contributed to the spread of disease and a change in diet. Numerous investigations suggest that the impact of early urbanisation on population health and diet is not homogeneous everywhere but varies based on the particularities of the region in question. The Caucasus is one such region. Located between the Black and Caspian seas it has always been characterised by vibrant cultural dynamism. It acted as a frontier between urban societies of the ancient Near East and the nomadic populations of the ancient Eurasian steppes. As such this is an excellent location to study the effect of urbanisation on health and diet. This dissertation focuses on paleopathological examinations of skeletal materials from the region of Caucasus, specifically the Greater Mtskheta territories located in the central part of the south Caucasus. The anthropological material from Greater Mtskheta forms one of the largest collections in the region. Human skeletal materials from 13 cemeteries, from three important time-periods were examined: the Late Bronze/Early Iron Age pre-state society with rural-type settlements (15th–6th centuries BC); the Antique period with the emergence of urbanisation and the establishment of the Iberian kingdom (5th century BC–4th century AD); and the Early Middle Age period with developed urbanisation and the collapse of the Iberian kingdom (4th–7th centuries AD). To observe the changes in health and diet throughout these different periods, pathological conditions such as porotic hyperostosis and dental diseases—caries, periapical lesions, antemortem tooth loss and calculus—were examined. Besides these pathologies, molecular analysis of dental calculus was done for these three periods. Statistically, there were no significant differences in lesions and the degrees of activity of porotic hyperostosis. But there was a significant trend in prevalence of porotic hyperostosis across time-periods and between sex. This indicated that deterioration in health conditions during the transitional periods was gradual and did not severely affect the population. The incidences of caries, periapical lesions, antemortem tooth loss and calculus throughout the periods may be associated with changing diet. An insignificant decrease of caries lesions during the urbanisation period may suggest diversification of food production and less dependence of grain consumption, rich in hydrocarbonates, which are responsible for caries.
A statistically significant difference in the oral microbiome in pre-and urbanised-state societies may be associated to an increase of frequency of porotic lesions on the skulls and the rise of abscesses over time. The decrease and low incidences of caries throughout the periods may be associated with the absence of specific bacteria in the oral microbiome of the ancient population of Georgia. This study is part of a growing body of research into the impact of early urbanisation on population health and diet. Using certain pathological changes on human skulls, together with analysis of dental diseases, and combining these with the study of oral microbiomes, it contributes to future research on similar topics. This is particularly relevant for the Caucasus, where this type of research has not yet been conducted.
Declaration

I declare that:

The thesis comprises my original work towards the degree of Doctor of Philosophy except where indicated in the Preface.

Due acknowledgement has been made in the text to all other materials used.

The thesis is 43,942 words in length, including tables, figures, and bibliography.

Marine Chkadua

December 2019
Preface

This dissertation includes collaborative work that has been contributed by others who are acknowledged here.

My principal supervisor Dr. Varsha Pilbrow provided guidance in designing the research project, formulating hypotheses, and developing the methodology and scoring rubrics for data collection. She contributed her ‘Physical Anthropology’ spreadsheet, which formed the basis for the data collection worksheet used in this thesis. Skeletal materials from the Pilbrow lab were used in testing the methodology developed for this study and Dr. Pilbrow assisted with the inter-observer error study.

Abby Robinson, Dr. Aleksander Michaelewicz and Dr. Pilbrow edited the language of the first draft of my thesis.

Assoc.Professor De longh helped to prepare final version of my thesis and edited the language.

I carried out 100% of the statistical analyses. A/Professor De longh and Dr. Pilbrow verified 100% of my results. The ‘Statistics Consulting Centre’ of The University of Melbourne, Yvette Wilson, Kiana Kakavand, Ia Kakichashvili and Nino Butsashvili provided guidance on carrying out statistical analyses in SPSS and Prism Pad.

I collected 100% of the data presented in the thesis and photos provided in the dissertation were taken by me.

The dental calculus was analysed at the Australian Centre for Ancient DNA, Adelaide by my co-supervisor Dr. Laura Weyrych and her team. Dr. Weyrych assisted with the interpretation of the results and provided assistance in editing Chapter Six.

Dr. Giorgi Bedianishvili assisted in preparing maps and figures.
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Besides my primary supervisor, I would like to thank my co-supervisors, Dr. Laura Weyrich and Dr. Tosha Dupras, my advisory committee members Assoc. Prof. Robb De longh and Dr. Simon Murray for their insightful comments and encouragement, but also for the challenging questions put to me which provided me incentive to widen my research from various perspectives. I am very grateful to the Anatomy department heads, Profs. Janet Keast and Gary Hime, and post-graduate coordinator, Dr. Peter Kitchener for their help and support.

Due to some difficult circumstances that appeared exactly at the end of my PhD, I want to express my deepest thanks and appreciation to Assoc. Prof. Robb De longh, for his support, help and encouragement. With his help it was possible to finish my thesis as he was the only person giving me feedback on my final draft of the thesis. No words can describe how grateful I am for his time, help, advices and suggestions.

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A special thanks to my family. Words cannot express how grateful I am to my parents and my sister, my mother-in law, sister- in law and brother-in law for all the sacrifices they made on my behalf.

At the end I would like to express my appreciation to my beloved husband, who spent sleepless nights with me and was always my support when there was no one to answer my queries. I want to thank also my children who were born during my study, who brought light into my stressful PhD student life, kept me entertained through my study and reminded me that there was different life other than a PhD student’s life.
# Table of Contents

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABSTRACT</td>
<td>III</td>
</tr>
<tr>
<td>DECLARATION</td>
<td>V</td>
</tr>
<tr>
<td>PREFACE</td>
<td>VI</td>
</tr>
<tr>
<td>ACKNOWLEDGEMENTS</td>
<td>VII</td>
</tr>
<tr>
<td>LIST OF FIGURES</td>
<td>XIII</td>
</tr>
<tr>
<td>LIST OF TABLES</td>
<td>XV</td>
</tr>
<tr>
<td><strong>CHAPTER I: INTRODUCTION</strong></td>
<td>1</td>
</tr>
<tr>
<td>1.1 PURPOSE</td>
<td>1</td>
</tr>
<tr>
<td>1.2 EPIDEMIOLOGICAL TRANSITIONS</td>
<td>3</td>
</tr>
<tr>
<td>1.3 PALAEOLOGICAL BASELINE OF PRE-SETTLEMENT HUNTER-GATHERER POPULATIONS</td>
<td>4</td>
</tr>
<tr>
<td>1.3.1 PHASE ONE OF THE FIRST EPIDEMIOLOGICAL TRANSITION: FROM PRE-SETTLED TO SETTLED AGRICULTURAL SOCIETY</td>
<td>7</td>
</tr>
<tr>
<td>1.3.2 PHASE TWO OF THE FIRST EPIDEMIOLOGICAL TRANSITION: DISEASE IN URBAN SETTLEMENTS</td>
<td>7</td>
</tr>
<tr>
<td>1.4 PARASITIC AND ZOONOTIC DISEASE</td>
<td>8</td>
</tr>
<tr>
<td>1.5 ORAL HEALTH</td>
<td>8</td>
</tr>
<tr>
<td>1.6 ORAL MICROBIOME, GENERAL HEALTH AND DIET</td>
<td>9</td>
</tr>
<tr>
<td>1.7 THE SECOND EPIDEMIOLOGICAL TRANSITION – LAST TWO CENTURIES</td>
<td>10</td>
</tr>
<tr>
<td>1.8 THE THIRD EPIDEMIOLOGICAL TRANSITION – MODERN PERIOD</td>
<td>11</td>
</tr>
<tr>
<td>1.9 EXPECTED OUTCOME</td>
<td>12</td>
</tr>
<tr>
<td><strong>CHAPTER II: ARCHAEOLOGICAL CONTEXT</strong></td>
<td>13</td>
</tr>
<tr>
<td>2.1 DEFINING THE RESEARCH AREA</td>
<td>13</td>
</tr>
<tr>
<td>2.2 HISTORIOGRAPHY OF BIO-ANTHROPOLOGICAL AND ARCHAEOLOGICAL INVESTIGATIONS IN MTSHETA</td>
<td>15</td>
</tr>
<tr>
<td>2.3 LATE BRONZE-EARLY IRON AGE CAUCASUS: PRE-STATE SOCIETY AND RURAL TYPE SETTLEMENTS</td>
<td>18</td>
</tr>
<tr>
<td>2.3.1 OVERVIEW OF THE REGION</td>
<td>18</td>
</tr>
<tr>
<td>2.3.2 SAMTAVRO CULTURE</td>
<td>21</td>
</tr>
<tr>
<td>2.3.3 SAMTAVRO VALLEY AND THE GREATER MTSHETA REGION</td>
<td>23</td>
</tr>
<tr>
<td>2.4 EMERGENCE OF STATE SOCIETY AND URBANISATION: SOUTH CAUCASUS REGION IN ANTIQUE PERIOD</td>
<td>25</td>
</tr>
<tr>
<td>2.4.1 GEOPOLITICAL OVERVIEW OF THE REGION</td>
<td>26</td>
</tr>
</tbody>
</table>
2.4.2 THE IBERIAN KINGDOM DURING THE ANTIQUE PERIOD .............................................. 26
2.4.3 GREATER MTSHKETA IN THE ANTIQUE PERIOD ....................................................... 28
2.4.4 SOUTH – WESTERN PART OF THE IBERIAN KINGDOM ............................................. 33
2.5 APEX OF THE DEVELOPMENT OF URBANISATION: SOUTH CAUCASUS REGION IN EARLY
MEDIEVAL PERIOD ............................................................................................................. 33
2.5.1 GEOPOLITICAL OVERVIEW OF THE REGION ............................................................. 34
2.5.2 THE IBERIAN KINGDOM IN THE EARLY MEDIEVAL PERIOD ...................................... 34
2.5.3 THE GREATER MTSHKETA IN EARLY MEDIEVAL PERIOD .......................................... 36
SUMMARY ......................................................................................................................... 38
2.6 HYPOTHESIS .............................................................................................................. 40

CHAPTER III: METHODS AND MATERIALS ...................................................................... 43
3.1 LOCATIONS AND STORAGE CONDITIONS OF THE ANTHROPOLOGICAL MATERIALS ...... 43
3.2 STORAGE CONDITIONS OF THE MATERIALS ................................................................. 45
3.3 PREPARATION FOR FIELD WORK ................................................................................. 45
3.4 DATA COLLECTION ....................................................................................................... 46
3.4.1 INCLUSION/EXCLUSION CRITERIA ............................................................................. 47
3.4.2 SKELETAL SPECIMENS COLLECTED ......................................................................... 48
3.5 ARCHAEOLOGICAL SITES REPRESENTED IN THIS STUDY ........................................... 51
3.6 SEX ESTIMATION ........................................................................................................ 56
3.7 STATISTICAL ANALYSIS ............................................................................................... 57

CHAPTER IV: POROTIC HYPEROSTOSIS .......................................................................... 58
4.1 INTRODUCTION ............................................................................................................. 58
4.2 METHODS ..................................................................................................................... 62
4.3 STATISTICAL ANALYSES ............................................................................................. 64
4.3 RESULTS - POROTIC LESIONS, DEGREE OF SEVERITY AND ACTIVITY ...................... 64
4.3.1 POROTIC HYPEROSTOSIS ......................................................................................... 64
4.3.2. DEGREE OF SEVERITY ......................................................................................... 68
4.3.3 DEGREE OF ACTIVITY ............................................................................................. 71
4.4 DISCUSSION ................................................................................................................ 74

CHAPTER V: DENTAL DISEASES – CARIES, PERIAPICAL LESIONS, ANTEMORTEM
TOOTH LOSS AND CALCULUS ............................................................................................. 77
5.1 ORAL HEALTH ............................................................................................................. 77
5.2 CARIES ........................................................................................................................ 77
5.3 PERIAPICAL LESIONS .................................................................................................. 79
5.4 ANTEMORTEM TOOTH LOSS ....................................................................................... 80
5.5 CALCULUS ..................................................................................................................... 80
5.2 METHODS AND MATERIALS ....................................................................................... 81
5.2.1 CARIES ...................................................................................................................... 82
5.2.2 PERIAPICAL LESIONS ............................................................................................... 83
5.2.3 ANTEMORTEM TOOTH LOSS ................................................................................... 83
List of Figures

Figure 1. MAP OF GEORGIA AND MTSHKETA REGION, ADAPTED FROM SAGONA ET. AL., 2010.13

Figure 2. RECONSTRUCTION OF ANCIENT MTSHKETA BASED ON ARCHAEOLOGICAL SITES (NIKOLAISHVILI, 2005) .................................................................................................................................. 30

Figure 3. MTSHKETA REGION MAP. 1-SAMTAVRO, 2-NICHIBIS KHEVI, 3-TSEROVANI, 4-
NATAKHTARI II, 5 BAIAKHEVI, 6- TSIKSAMURI III, 7-SVETITSKHOVELI, 8-BARGIKARIA, 9-
KAMARAKHEVI, 10-MARTAZIS KHEVI, 11- AVCHALISKARI, 12-TSILKANI, 13-KLDE ....... 50

Figure 4. MAP OF GEORGIA WITH LOCATIONS OF MTSHKETA REGION AND KLDE

ARCHAEOLOGICAL SITE ........................................................................................................ 50

Figure 5. EXAMPLES OF POROTIC LESIONS ACCORDING DEGREE OF SEVERITY, LOCATION AND
ACTIVITY USING THE STANDARDS OF BUUKSTRA AN UBE LAKER (1994), MODIFIED FROM
STUART-MACADAM (1985). A. DEGREE-1, LOCATION-1, ACTIVITY-0 (SAMTAVRO
CEM ETERY). B. DEGREE-2, LOCATION-1, ACTIVITY-3 (TSIKHEDIDIS KHEVI). C. DEGREE –
3, LOCATION – 1, ACTIVITY – 3 (NATAKHTARI). D. DEGREE – 3, LOCATION – 1, ACTIVITY
– 1 (NATAKHTARI). E. DEGREE – 1, LOCATION – 4, ACTIVITY – 0 (NICHIBIS KHEVI). F.
DEGREE – 2, LOCATION – 4, ACTIVITY – 3 (NATAKHTARI). G. DEGREE – 2, LOCATION – 5,
ACTIVITY – 2 (MARTAZIS KHEVI). H. DEGREE – 2, LOCATION – 1, ACTIVITY – 2
(SAMTAVRO CEMETERY) ........................................................................................................ 63

Figure 6. PERCENTAGE OF PREVALENCE OF POROTIC LESIONS ACROSS TIME-PERIODS. THERE
APPEARED TO BE SIGNIFICANT TREND FOR INCREASED PREVALENCE OF POROTIC LESIONS
FROM LATE BRONZE AGE TO ANTIQUE PERIOD AND EARLY MIDDLE AGES ................. 67

Figure 7. PRESENCE/ABSENCE OF POROTIC HYPEROSTOSIS BETWEEN SEX ....................................67

Figure 8. PERCENTAGE OF THE PREVALENCE OF POROTIC HYPEROSTOSIS BETWEEN SEX ACROSS
TIME-PERIODS. A TREND OF INCREASED POROTIC LESIONS HAS BEEN DETECTED BETWEEN
FEMALES ACROSS TIME-PERIODS .................................................................................. 68

Figure 9. PERCENTAGE OF DEGREE OF SEVERITY ACROSS TIME-PERIODS .................................... 69

Figure 10. PERCENTAGE OF THE DEGREE OF SEVERITY BETWEEN SEX .................................. 70

Figure 11. PERCENTAGE OF THE DEGREE OF SEVERITY BETWEEN SEXES ACROSS TIME-PERIODS
.............................................................................................................................................. 71

Figure 12. PERCENTAGE OF DEGREE OF ACTIVITY ACROSS TIME-PERIODS ................................. 72

Figure 13. PERCENTAGE OF THE DEGREE OF ACTIVITY BETWEEN SEX .................................. 73

Figure 14. DEGREE OF ACTIVITY BETWEEN SEXES ACROSS TIME-PERIODS ............................ 74

Figure 15. ABSCES OF RIGHT MANDBULAR P1 SHOWING A LINGUAL DRAINAGE CHANNEL
(RED ARROW) FROM THE ROOT APEX THROUGH THE ALVEOLAR BONE ......................... 83

Figure 16. PREVALENCE OF CARIES ACROSS TIME-PERIODS. THE DATA SUGGEST THERE IS A
DECREASING TREND ACROSS THE PERIODS; HOWEVER, THIS WAS NOT SIGNIFICANT
(p=0.364) ................................................................................................................................... 86

Figure 17. PREVALENCE OF CARIES BETWEEN SEX ........................................................................... 87

Figure 18. PREVALENCE OF CARIES BETWEEN SEXES ACROSS TIME-PERIOD ....................... 88

Figure 19. PREVALENCE OF CARIOUS LESIONS PER TOOTH ACROSS TIME-PERIODS ........... 89

Figure 20. PREVALENCE OF CARIOUS LESIONS PER INDIVIDUAL BETWEEN SEX ................ 90
FIGURE 21. PERCENTAGE OF THE CARIOUS LESIONS PER INDIVIDUAL BETWEEN SEX ACROSS TIME-PERIODS ................................................................. 91
FIGURE 22. PERCENTAGE OF PERiapical LESIONS ACROSS TIME-PERIODS ................................................. 92
FIGURE 23. PERCENTAGE OF PERiapical LESIONS BETWEEN SEX ... 92
FIGURE 24. PERCENTAGE OF PERiapical LESIONS BETWEEN SEX ACROSS TIME-PERIODS .......... 93
FIGURE 25. PERCENTAGE OF CASES OF PERiapical LESIONS AMONG THREE TIME-PERIODS ...... 94
FIGURE 26. PERCENTAGE OF CASES OF PERiapical LESIONS BETWEEN SEX .............................................. 95
FIGURE 27. PERCENTAGE OF CASES OF PERiapical LESIONS BETWEEN SEX ACROSS TIME- 
PERIODS ................................................................. 96
FIGURE 28. PERCENTAGE OF AMTL ACROSS TIME-PERIODS ................................................................. 97
FIGURE 29. PERCENTAGE OF ATML BETWEEN SEX ........................................................................ 98
FIGURE 30. PERCENTAGE OF AMTL BETWEEN SEX ACROSS TIME-PERIODS ........................................ 98
FIGURE 31. PERCENTAGE OF THE SEVERITY OF AMTL ACROSS TIME-PERIODS ................................. 99
FIGURE 32. PERCENTAGE OF SEVERITY OF AMTL BETWEEN SEX .................................................... 100
FIGURE 33. PERCENTAGE OF SEVERITY OF AMTL BETWEEN SEX ACROSS TIME-PERIODS .......... 101
FIGURE 34. PERCENTAGE OF PREVALENCE OF CALCULUS ACROSS TIME-PERIODS .............. 102
FIGURE 35. PERCENTAGE OF PREVALENCE OF CALCULUS BETWEEN SEX ........................................ 102
FIGURE 36. PERCENTAGE OF PREVALENCE OF CALCULUS BETWEEN SEX ACROSS TIME-PERIODS .......... 103
FIGURE 37. PERCENTAGE OF PREVALENCE OF EACH DENTAL PATHOLOGY ACROSS TIME-PERIODS ................................................................................................................................. 103
FIGURE 38. PERCENTAGE OF PREVALENCE OF EACH DENTAL PATHOLOGY BETWEEN SEX ...... 104
FIGURE 39. DEGREES OF FORMATION OF CALCULUS: MANDIBLE LEFT SIDE. TOOTH P1 –
   DEGREE1/ LABIAL/SUPRAGINGIVAL; P2 -DEGREE2/LABIAL/SUPRAGINGIVAL; M1 –
   DEGREE3/LABIAL/SUPRAGINGIVAL.................................................................................. 108
FIGURE 40. BETA DIVERSITY: BETWEEN SAMPLE DIVERSITY ................................................................. 115
FIGURE 41. BACTERIAL PHYLA LEVEL........................................................................................................ 117
List of Tables

TABLE 1. SKELETAL COLLECTION AND DENTAL CALCULUS SAMPLES ACROSS TIME-PERIODS.
   This table shows the total number of crania studied at each site, as well as the breakdown of the individuals by time-period. Also shown are the dental plaque samples collected from each site (*) and time-period. ........................................49
TABLE 2. SEX DISTRIBUTION ACROSS TIME-PERIODS ........................................................................57
TABLE 3. POROTIC LESIONS ACCORDING DEGREE OF SEVERITY, LOCATION AND ACTIVITY .........62
TABLE 4. DISTRIBUTION OF POROTIC LESIONS AMONG TIME-PERIODS, BETWEEN SEX AND BETWEEN SEX ACROSS TIME-PERIODS .......................................................................................66
TABLE 5. SKELETAL SPECIMENS ANALYSED FOR DENTAL PATHOLOGY ..............................................82
TABLE 6. DISTRIBUTION OF CARIOUS LESIONS ACROSS TIME-PERIODS AND IN SEX ACROSS TIME-PERIODS ..........................................................................................................................86
TABLE 7. THE DEPTH OF SEQUENCING OF ALL THE MATERIALS .......................................................112
TABLE 8. STATISTICS OF PRE AND URBANISED STATE SOCIETIES .................................................118
Chapter I: Introduction

1.1 Purpose

Currently, more than half of the world’s population lives in cities. Studies of modern urban living have suggested there are increased risks associated with disease outbreaks in densely populated places, as well as increases in air pollution, car accidents, cardiovascular and respiratory diseases and diabetes (Leon, 2008); also for more details see World Health Organization 2010). The same negative effect is linked to the emergence of urbanisation in historic periods, when densely populated, cites had problems of hygiene. The resultant increased human waste and contaminated drinking water likely resulted in increased epidemic diseases such as typhus and cholera, which occurred to a greater scale in cities than in rural settlements (Pedersén, 2010). Urbanisation is also connected to the diversification of food consumption, as urban society unlike to rural population is not strictly rely on agricultural on pastoral activity only (Readron, 2014). The emergence of urbanisation and its level of impact on the population’s health and diet varied based on the region. Bio-anthropological studies suggest that the severity of deterioration of health as a result of urbanisation is not the same everywhere (Betsinger & DeWitte, 2017; Haishan Chen et al., 2016). It might be connected to the process of urbanisation which developed differently in each part of the world. Cohen and Crane-Kramer (2007) suggest that there are no uniform standards to understand the impact of transitional periods on population’s health across different regions. Therefore, it is impossible to rely only on comparison with other cases.

Based on previous studies (Larsen, 1997, 1998; Vuorinen et al., 2007) highlighting the impact of urbanisation on diet and human health in various different contexts (for example: Medieval Sweden (Kjellström, 2014) and Poland, (Betsinger, 2007a)), it can be hypothesised that in the Mtskheta region there was increased urbanisation, driven by demographic growth and establishment of Iberian kingdom, and that this affected human health. In particular we hypothesised that changing diets and growth of densely populated city over these epochs had detrimental effects on oral and bone health.

The main purpose of this study is to find out how and to what extent urbanisation impacted on the health, mode of life and diet of the population in the Mtskheta region of Georgia from the Late Bronze Age to the Early Middle Ages. In order to what extent urbanisation declined quality of life, a bioarchaeological analysis of skeletal samples was conducted. This dissertation investigates not only the general impact of urbanisation on the
population's health in the south Caucasus, but likewise tries to understand the degree of this impact and its relevance to the socio-economical processes occurring within the region. Human skeletal samples (105 specimens) from 13 archaeological sites from the Mtskheta region and representing three time-periods – Late Bronze Age (pre-urban), Antique period (early urban) and Early Middle Ages (late urban) are included in the study.

The paleopathological research presented here deals with Georgia - the south Caucasus region, where this type of study has never been undertaken before. Comparison of dental pathologies and porotic hyperostosis from pre-urban and urban period of Mtskheta suggests that urbanisation did not dramatically effected population, rather then it was more gradual process. The data described in this dissertation contributes to a larger body of work that has studied the effects of urbanisation on human health in various parts of the world at different time-periods throughout history.

In order to examine the hypothesis that urbanisation had adverse effects on the health condition of the Greater Mtskheta population, I focused on examining the prevalence and severity of skeletal disease markers (porotic hyperostosis, PH), and indicators of dental diseases (caries, dental calculus, periapical lesions, ante mortem tooth loss, AMTL) in samples of cranial bone and teeth obtained from archaeological excavations in the Mtskheta region, dating from three time-periods (Late Bronze Age, Antique period and Early Middle Ages).

Although these skeletal pathologies will be described in greater detail in the subsequent chapters, the reasons for focusing on these pathologies is described here briefly. Porotic hyperostosis which is a multifactorial stress marker mostly linked with anaemia (Aufderheide & Rodriguez-Martin, 2006; Walker, Rhonda, et al., 2009), is the most common pathological condition detected on skeletal remains from archaeological sites. Caries, which is mainly caused by oral bacteria Streptococcus mutans and Lactobacillus (Kutsch, 2014), is the most prevalent among the dental diseases and its appearance is associated with the emergence of agriculture (Aufderheide & Rodriguez-Martin, 2006; Hillson, 2001; Waldron, 2009). Sreebny (1983) in his study has compared world-wide data on rice, wheat and maize supplies from the countries that had high and low consumption rates. According to the study wheat had positive and maize negative correlations with dental caries and rice had no association with the dental disease. Comparing to hunter-gatherers, caries frequencies are higher in people who were based on gardening, farming and mixed economies (Hillson, 2001; Lukacs, 1992). According to palynological analysis in Kartli region (where Mtskheta is located), several types of wheat and
flax were cultivated. In this region with gardening and viticulture, beekeeping was also well developed (Kvavadze, 2014). Periapical lesions are considered the most frequently occurring pathological lesions affecting the alveolar bone. It may occur as a result of pulpal inflammation but can also be seen in the absence of pulpal diseases (Akinyamoju, 2014). Ante Mortem Tooth Loss can be caused due to several reasons – extraction, scurvy or trauma. However, the most frequent reason is considered to be periodontal disease. Pathogenic bacteria such as Porphyromonas Gingivalis, Tannerella Forsythensis, Treponema Denticola, and Actinobacillus Actinomycetemcomitans cause development of this disease. These bacteria, during bleeding of the gums, which is caused by the accumulation of plaque, generates cytokines. As a result, inflammation develops, which causes tooth loss and alveolar bone destruction (Waldron, 2009). Dental calculus is the main source of the oral microbiome for archaeological material. It is a calcified bacterial biofilm that is formed from dental plaque, saliva and gingival crevicular fluid (Waldron, 2009; Warinner et al., 2014). The oral microbiome is a good indication of diet, migration and general health (Weyrich et al., 2015a). Taken together, these skeletal markers provide a broad picture of life conditions in the Greater Mtskheta region and generate insights into the health of Greater Mtskheta populations in the Late Bronze Age, Antique and Early Middle Ages.

Skeletal materials were analysed to understand the impact of urbanisation on the population’s health in Greater Mtskheta and its adjacent region

1.2 Epidemiological transitions

As outlined by Armelagos et al. (2009; 1996), starting from a baseline of Paleolithic hunter-gatherer populations there were three main epidemiological transitions associated with a significant increase in infectious and nutritional diseases in human history. The first epidemiological transition is connected with the end of the Palaeolithic period and can be divided into two phases: (1) the beginning of the Neolithic, when populations switched from a mobile hunter-gathering subsistence to a sedentary agricultural mode of lifestyle, and (2) urbanisation, when large cities were established. The second epidemiological transition occurred in the last 200 years and is marked by the emergence of public health measures and a decline in infectious diseases in developed worlds, but an increase in non-infectious, chronic
and degenerative conditions (Armelagos, 2009). The third epidemiological transition occurred in the modern period about 30 years ago, when new diseases such as Argentine hemorrhagic fever, Hantavirus pulmonary syndrome and others emerged due to ecological changes, and infectious diseases resistant to antibiotics appeared (Armelagos, 2009).

Urbanisation is considered as one of the most significant changes in the history of human settlement. Throughout the history of human settlement, starting from a nomadic lifestyle, continuing on to sedentary agricultural settings and further to urban and industrialized times, humans have had a close relationship with infectious and non-infectious diseases. Infectious diseases are caused by pathogens such as viruses, bacteria and parasites. Non-infectious diseases are mostly related to age and degenerative changes. Over the long period of coexistence with humans, pathogens have gradually evolved and as a consequence, shifts in human lifestyle accompanied the appearance of new diseases (Armelagos G.J., 1996; Armelagos et al., 1996; Greger, 2007). These affected the demography of ancient populations and significantly influenced our history (Crawford, 2007).

1.3 Palaeolithic baseline of pre-settlement hunter-gatherer populations

Hunting and gathering is the earliest subsistence strategy of ancient humans, practiced from the start of the Palaeolithic period, about 3 million years ago (Barker, 2006). In the scientific literature there are many definitions of the hunter-gatherer subsistence (for the most recent synthesis on the definitions of hunter-gatherer societies see (Barker, 2006; Smith et al., 2004). One of them is “the absence of direct human control over the reproduction of exploited species and little or no control over other aspects of population ecology” (Panter-Brick et al., 2001). One of the main characterisations of the hunter-gatherer society is their mobility. People lived in small groups, typically did not build houses and subsequently did not try to store food (Barker, 2006). Hunting and gathering thus includes fishing and hunting of wild animals and gathering different types of plants that were not yet domesticated (Lee, 1999). Physical anthropological studies show that because of their lifestyle and diet, hunter-gatherers had fewer diseases compared to later periods (Armelagos, 2009). The wild plants and animals they consumed came from their local environment. Their food was rich in protein, polyunsaturated and monounsaturated fats, vitamins, minerals and many other beneficial phytochemicals (O'Keefe & Cordain, 2004).
It is believed that compared to later periods the food of prehistoric hunter-gatherer populations contained a large number of non-pathogenic bacteria that was good for their health (Bengmark, 2000). A good example is that of Australian aboriginal populations pre-European contact (Webb); Webb (1995) showed that aboriginal hunter-gatherer populations had fewer infectious diseases and had much better health before 1788, when colonizers introduced a different lifestyle and new diseases that the Aborigines had never been exposed to and thus had no resistance to.

Although it is believed that hunter-gatherer populations were healthier than subsequent populations, they harboured various types of parasites. Parasites like *Taeniidae tapeworms* existed in the Palaeolithic period, long before of the development of agriculture and animal domestication. They were transmitted to humans through the animals they hunted (Hoberg et al., 2000). Two types of parasitic species are distinguished among hunter-gatherer populations (Kiks, 1990). The first type, “Heirloom species,” comprise parasites like head and body lice, pinworms, yaws and malaria that are unique to humans and are zoonotic (can be transmitted from animals to humans). The second type, “Souvenir species,” were transmitted through insect and animal bites or by eating contaminated animal flesh (Piers, 2013). Diseases transmitted through such species include tuberculosis, typhus and tularaemia (Kiks, 1990); (Armelagos, 2009). Although there were various types of diseases in the Palaeolithic period, it is believed that because of small population sizes and a mobile lifestyle of hunter-gatherers, these diseases were not widespread and did not have a significant impact on the demography of Palaeolithic populations (Kiks, 1990).

In the territory of modern Georgia there is evidence for all periods of the Stone Age (Gabunia, 2015). Caves dating from Lower Paleolithic age and characterised by Oldowan stone tool technology, have been found at Dmanisi and dated to 1.7-1.8 Ma. Damanisi Oldowani period stone tools are characterized by simple forms with several flakes, whereas Acheulian stone technology, that already have stone handaxes, has been identified at Kudaro cave I, Kudaro cave III, Tsona cave and 84 other sites that are less well documented (Gabunia, 2015). Representation of the Middle Paleolithic age is reflected by Mousterian flint tools which are characterized by stone blades mounted on shafts. This period is asssociated with the Neanderthals, at Apiancha, Double cave, Djurchula cave, Bronze cave, Ortvala kide, Ortvala cave and 130 other less well documented sites. Similarly, evidence for the Upper Paleolithic age has been documented at Dzudzuana cave, Satsurblia cave, Sgavardjile cave and 55 other sites. In this period together with stone tools, bone and wood tools are appearing as well (Gabunia, 2015). The Mesolithic division of the Stone age on the teroitory of Georgia is
represented by 30 odd sites including Darkveti cave, Kotias klde, and Tsivi cave. This period is associated with the appearance of microscrapers and trapezoids mostly in the western part of Georgia, along the Black Sea shore and scalene triangles in the central part of Georgia.

Generally in the territory of Georgia there are six main regions, where Stone Age (From Lower Paleolithic to Mesolithic period) sites are distributed: 1. The Black Sea coast; 2. The Rioni-Kvirila basin; 3. Shida Kartli; 4. Kvemo Kartli; 5. Javakheti mountainous region; and 6. The Iori-Alazani basin. Other regions of Georgia such as Guria, Racha, Lechkhumi, Svaneti and even Kvemo Kartli are characterized by relatively small number of sites (Gabunia, 2015). People in the Stone Age commonly inhabited caves and rock shelters that were located in the canyon-like places along rivers. One of such site is Dmanisi, which is the oldest paleolithic site outside of Africa and was occupied by Homo (Mgeladze, 2011). Similar site to Dmanisi is also Amiranis gora (Javakheti) and Ziari (Kakheti) (Gabunia, 2015).

Recent studies of the region of western Georgia have shown that the region was occupied by Palaeolithic hunter-gatherers (Meshveliani, 2007). Faunal findings of the Black Sea coastal caves mostly include bones of mammals (95%), with bones of birds, fish, and a few bones of amphibians and reptiles making up the remainder (Burchak-Abramovich, 1982). The diet of hunter-gatherers in Georgia showed regional variability, with the faunal list in the caves of eastern Georgia mostly consisting of bison, deer, wild goat (Capra caucasica), and horse. Whereas in western Georgia the faunal list included wild boar but not horse bones (Burchak-Abramovich, 1982). Palynological analysis at Satsurblia cave showed that sediments were rich in broad-leafed plants, pollen with walnut, also pollen of hazel and pine. The presence of large quantity of phytoliths, cereal starch grains, and Poaceae in the pollen spectra suggests that wild cereals were important and substantial components of the diet of Satsurblia cave inhabitants in the Palaeolithic period (Phinasi, 2014). However, it remains to be determined if these cereals are as common and widespread at other sites as most of the Stone Age caves and sites in Georgia are still under investigation (Meshveliani, 2007).

Neolithic period that appears after Mesolithic period is final division of the Stone Age in the Caucasus region. It is devided into two parts - Aceramic (Early) and Ceramic (Late) period. Early Neolithic period that can be considered as a transitional period from hunter gathering to agricultural and pastoral lifestyle. However, because of lack of data this period is less known. As for the Late Neolithic period, it is linked to the appearance of first settlements and domestication of plants and animals. In the territory of Georgia, Late Neolithic sites has been documented at Gadachrili gora, Arukhlo, Imiris gora and 37 other sites (Chataigner, 2014).
1.3.1 Phase One of the first epidemiological transition: From pre-settled to settled agricultural society

Southwest Asia, the territory of modern Iran and Iraq, is claimed to be the first place where, about 10,000 years ago, humans started to have a sedentary lifestyle by intentionally cultivating plants and domesticating animals (Simmons, 2007). Compared to the previous period (Mesolithic), this socioeconomic change, known as the Neolithic revolution, required more work and greater social complexity, and was associated with greater health problems (Simmons, 2007).

While there are numerous Palaeolithic caves and sites in Georgia, there is little information about when a shift from hunter-gatherer lifestyle to agriculture subsistence occurred in the territory of Georgia. Despite this, several hypotheses exist with regards to replacement of Palaeolithic local dwellers with agro-pastoral societies. One school of thought is that farmers migrating from Anatolia brought with them agricultural knowledge and expertise, also known as an “agricultural package” (Chataigner, 2014). An alternative hypothesis is that local Mesolithic foragers acquired agricultural skills and knowledge through their dispersal over a wide range and subsequently implanted this gradually in the river valleys of Mtskheta (Meshveliani, 2007).

1.3.2 Phase two of the first epidemiological transition: Disease in urban settlements

Urbanisation in the ancient world was connected with stratification of complex societies, centralization of food resources, developing craft specializations and enlarging trade networks with adjacent regions (Cowgill, 2004; Rosen, 1997). The ancient cities were densely populated, often holding several thousand inhabitants, with attendant problems of hygiene on a greater scale than occurred in rural settlements (Pedersen et al., 2010). In particular, contaminated drinking water and increased human waste resulted in increased epidemic diseases such as typhus and cholera (Armelagos, 2009; Betsinger, 2007b). Typical examples are Ancient Greece and Rome. Although they were aware of methods to maintain pure portable water, such as having water tanks, filters and even boiling water, they did not always follow these methods and drinking water was often contaminated (Nutton, 2013). There were also problems with toilet hygiene as common toilets were often placed near kitchens, which would have led to the spread of intestinal diseases (Vuorinen et al., 2007). Viral disease such as
measles, mumps, chicken pox and smallpox would have spread, due to crowding of the populace in large centres. Social hierarchization and inequality heightened the problems related to hygiene. In Roman towns, socially advanced echelons of the population had access to running water and private toilets, whereas lower class echelons obtained water from public places and used public toilets and baths, which was the source of Tuberculosis and respiratory diseases such as pneumonia, bronchitis and diphtheria (Vuorinen et al., 2007).

1.4 Parasitic and zoonotic diseases

The beginning of farming is associated with an explosion of parasitic and zoonotic diseases (Armelagos, 2009). Unlike hunter-gatherers, sedentary populations deposited human waste near water resources. In addition, concentrated contact with domesticated animals increased the likelihood of zoonotic diseases, such as anthrax, Q fever, tuberculosis, brucellosis, scrub typhus and malaria (Armelagos, 2009; Barrett et al., 1998; Kuo et al., 2012). A modern-day study in West Africa showed that slash-and-burn agriculture exposed the population to the mosquito, Anopheles gambiae, which transmitted Plasmodium falciparum, causing malaria (Armelagos G.J., 1996; Coluzzi, 1999; Joy et al., 2003). In another example from Medieval south Italy, irrigation channels led to an explosion of malaria (Reinhard et al., 2013). It should be clarified that if in the Old World the increase of zoonotic diseases was connected with the introduction of farming activities, the same cannot be said about the Americas. Recent research by Reinhard et al. (2013) showed no significant changes in the frequency of zoonotic diseases in the transitional period from hunter gathering to agriculture in the New World. On the other hand, there was a radical increase in zoonotic diseases after the appearance of the first Europeans, who introduced beef and pork tapeworm, and sheep liver lancet flukes from their domestic animals.

1.5 Oral health

The introduction of agriculture has been associated with an increase in oral disease (Armelagos, 2009). It has been reported that caries become more frequent with the consumption of high-carbohydrate agricultural food (Houte, 1994; Larsen, 2006). For example at the Verbeta cave site of the Tripolye culture (4300-4000 B.C) in prehistoric Ukraine, the
incidence of caries was 9.5% among individuals practicing agriculture and consuming grain, whereas among hunter-gatherers there was no incidence of caries (Karsten et al., 2015).

While linked to an agricultural lifestyle, a study of caries may also provide important information on gender and status-based access to food. At the Classical Maya site of Calakmul, dated to the 250-900 AD, females from higher social groups had much higher number of caries than males; whereas in lower social classes both genders had the same rate of caries. This was interpreted as indicating that elite male food consumption was based more on animal protein whereas elite female food included a greater consumption of carbohydrates that caused caries (Cucina & Tiesler, 2003). It should be noted, however, that in general, the incidence of caries is higher in females than males (Lukacs & Largaespada, 2006). In their study by analysing the factors causing development of caries, Ferraro and Vieira (2010) attempted to provide an explanation how the variables differ in males and females. Genetic factor of caries development can be linked to genes presented on X or Y chromosome. The Amelogenin (AMELX) which is located on p arm of X chromosome, is believed to be a responsible for enamel formation as it seems this gene and its protein creates 90% of the enamel matrix. A deficient of amelogenin gene or decreased amount of amelogenin protein can lead to disruption of formation of enamel matrix that can increase susceptibility of caries. Alternatively, this may be related to the composition and flow rate of saliva, which is believed to play a less protective role in females. Similarly, hormonal changes related to pregnancy may also compromise the immune system of females, leading to an increase in caries (Ferraro & Vieira, 2010; Lukacs & Largaespada, 2006).

1.6 Oral microbiome, general health and diet

An exciting new avenue of research on health in the Neolithic transition focuses on high-resolution taxonomic characterization of the oral microbiome of ancient populations (Warinner et al., 2014). The term microbiome was first introduced in 2001 by Joshua Lederberg to describe microorganisms that live in the human body and can be used to reconstruct an individual’s health (Lederberg & Mccray, 2001). As reviewed by Warriner and others (Warinner et al., 2014), the human oral microbiome contains more than 2000 bacterial taxa and innumerable pathogens. It provides significant information on the evolution and interaction between the human microbiome, health and diet. For archaeological material the main source of the oral microbiome is dental calculus, the calcified bacterial biofilm that is formed from
dent tissue. It preserves very well after death and is a direct source of material for not only studying the oral health of the deceased from plaque mediated infections (Adler et al., 2013; Larsen, 1997), but also for providing an indication of diet during life.

Using dental plaque from a medieval site in Germany, Warinner et al. (Warinner et al., 2014) found that several types of bacteria known to be associated with periodontal, cardiovascular and respiratory disease today were prevalent to an even greater degree in the medieval period. They also characterized about 25 pathogens providing immunological resistance (Adler et al., 2013) from DNA extracted from dental calculus of archaeological samples from Europe dating from the Mesolithic (7,550 – 5,450 BC) to the Late Medieval period (400 – 1000AD) and compared their oral microbiome with that found in modern Europeans. As predicted by the epidemiological transition hypothesis, they found that Mesolithic hunter-gatherer populations had fewer carious lesions and periodontal diseases, but from the Neolithic period onwards, with the introduction of agriculture, there was a radical increase in these oral pathogens. They surmised that carries and periodontal diseases were caused by carbohydrate-heavy food that was introduced with the onset of agriculture in the Neolithic period (Adler et al., 2013). The rate of oral disease remained the same during the Medieval period. As clarified by various researchers (Adler et al., 2013; Larsen, 1997; Warinner et al., 2014; Weyrich et al., 2015b) dental plaque is long lasting, simple to extract and provides a host of benefits in studying oral health. It also provides a long and detailed record of pathogens responsible for cardiovascular and other systemic diseases such as diabetes and arthritis as it is possible to identify immunological strains that provide resistance, it can be used to trace population movement and migration, and it can provide independent verification of skeletal markers of disease. Thus data from caries analyses can counter the osteological paradox (an important consideration for paleopathology, explained in greater detail below) (Warinner, Speller, & Collins, 2015). As a new area of research, it has immense potential for using archaeological samples particularly from the time of the Neolithic transition to study the inception of several health concerns of the present day.

1.7 The second epidemiological transition – Last two centuries

The second epidemiological transition is connected to the increase of chronic and degenerative diseases that have appeared in the last 200 years. Although genetic factors can be
responsible for some chronic and degenerative diseases it is believed that there are other main factors that determines the second epidemiological transition (Harper & Armelagos, 2010).

There are two factors that have contributed to the augmentation of chronic and degenerative diseases. Firstly, modern achievements in medicine have made it possible for people to live much longer than previously. Modern medical technologies also make it possible to better control infectious diseases. Some specialists have explained the decrease in infection rates to a better understanding of the origin of diseases, while others have linked it to immunisation (Armelagos, 2009). The second main factor contributing to the second transitional period is considered to be environmental, such as pollution, mental stress, malnutrition connected to diabetes and heart diseases, which were less prevalent in the previous two centuries (Harper & Armelagos, 2010). As Armelagos (2009) argues, the second epidemiological transition is socially and geographically different. It appears in counties where medicine is well developed and among social classes that have access to abundant food and appropriate medical services.

1.8 The third epidemiological transition – Modern period

The third epidemiological transition started quite recently, approximately 30 years ago (Greger, 2007), and involves emergence of bacteria and viruses with antibiotic resistance that led to re-emergence of previously controlled diseases. Ecological changes such as deforestation, dam constructions, agricultural development projects, droughts and floods have led to the appearance of diseases such as Argentine hemorrhagic fever, Hantavirus pulmonary syndrome and Hantavirus (Korean hemorrhagic fever) in areas where they had not been encountered previously. According to the Director of the Centers for Disease Control in Atlanta GA, the last 22 years have seen the emergence of over 22 totally new diseases caused by different microorganisms including Ebola, Ritovirus, HTLV II, Hepatitis C, Legionella pneumophila, Staphylococcus, Escherechia coli 0157:h7, HIV, Human herpes virus 6 and Hantavirus isolates. However, previously prevalent infectious diseases, such as tuberculosis that is 3 million years old still exist and according to World Health Organization (WHO), even today tuberculosis infects millions of people in the world and hundreds of thousands of deaths are reported as a result of parasitic and infectious diseases (Armelagos G.J., 1996; Armelagos, 2009; Harper & Armelagos, 2010).
1.9 Expected outcome

Until now the paleopathology of Mtskheta region – Georgia (south Caucasus) has not been reconstructed within the context of the epidemiological transition. The time frame of the examined materials includes one significant transitional period (Increased urbanisation), spanning from the Late Bronze Age (15th century BC) through the Early Middle Ages (6th century AD). Throughout these two millennia, the emergence of urbanisation in the Caucasus region was a slow process. The assumption being that health changes proceed in step with the growth of population. The same can be said about changes in diet and mode of lifestyle from pre-urban to urban societies, which is expected to be a gradual and not a severe transition.
Chapter II: Archaeological context

2.1 Defining the Research Area

The focus of this research is the territory of Mtskheta, Georgia, and its surrounding areas, known as Greater Mtskheta, which is located in the central part of eastern Georgia on the confluences of Kura (Mtkvari) and Aragvi (Aras) Rivers, 21 km north of the modern capital of Georgia (Figure 1).

Figure 1. Map of Georgia and Mtskheta region, adapted from Sagona et al., 2010
The territory of Greater Mtskheta covers about 15 square kilometres. It is bordered in the north by the Saguramo range, in the south by the Kura River, in the east by the Tsitsamuri valley and in the west by the Kartli mountains. The lowest elevation in the territory of Greater Mtskheta is the modern town of Mtskheta, at an altitude of 480 m above sea level. The highest point is northeast of the town on the opposite, left bank of the Aragvi River at Zedazeni, which reaches an altitude of 1250 m above sea level. Generally, the territory of Greater Mtskheta is characterised by a diversity of landscapes, including gorges, open valleys, mountains, and small rivers connected to the Kura and Aragvi Rivers (Demetradze, 2014).

In ancient times, Mtskheta was located at the crossroads of important trade routes. Through Mtskheta, the central part of the south Caucasus mountains was connected to the northern Caucasus, western Georgia, Azerbaijan, and Armenia. The great Silk Road that was active in the 2nd century BC from China to the Black and Mediterranean Seas, also went through Mtskheta (Berdzenishvili, 1964). The Samtavro cemetery, discovered in 1871 in Mtskheta, became the eponymous site for the Late Bronze Age (15th – 6th cc. BC) of the central south Caucasus. In the Antique period (5th c. BC – 4th c. AD), Mtskheta was the capital of the Iberian kingdom, and it was one of the important political and economic centres of the whole Caucasus region. The territory of Greater Mtskheta is located in the corridor connecting western and eastern parts of the south Caucasus mountains, as well as linking the north eastern Anatolian regions to the North Caucasus mountains (Berdzenishvili, 1964).

In Mtskheta there are a large number of archaeological sites. The chronological range of these sites span from the Early Bronze Age to the Late Medieval period. Most of these sites, however, are dated to three periods: Late Bronze Age (15th - 6th centuries BC), Antique period (5th century BC – 4th century AD), and the Early Medieval period or Early Middle Ages (4th - 6th centuries AD).

Archaeological sites from Mtskheta have played an important role in defining the chronology of the Late Bronze/Early Iron Ages, Antique and Early Medieval period of the south Caucasus region (Sadradze, 2002). Almost all specialists working on the chronology of these periods in the south Caucasus region, and especially its central part, include archaeological sites discovered in the territory of Mtskheta in their works. For an overview of the literature, where the Mtskheta region is discussed in relation to the chronology of the south Caucasus, see (Sadradze, 2002).
2.2 Historiography of bio-anthropological and archaeological investigations in Mtskheta

Because of its rich archaeological record, Mtskheta serves as a main source for understanding the historical civilizations of the Caucasus region. It also plays an important role in understanding the formation of physical anthropology and archaeology as disciplines in the Caucasus region. Mtskheta was one of the first areas in the region where systematic archaeological excavations were conducted. The first archaeological investigations started in 1867 when, during the construction of the Military Road, a Roman-period inscription was discovered (Bayern, 1872). Later, in 1871, the Samtavro cemetery was discovered near the Medieval Samtavro monastery, and this hitherto unknown site soon attracted the attention of specialists. Frederic Bayern, a specialist from the Tbilisi Museum, started excavations at Samtavro cemetery and from 1871 to 1876 he uncovered 604 graves (Bayern, 1872).

Bayern can be considered not only as a pioneer of archaeological investigations in Mtskheta, but also as a pioneer in bio-anthropological research in Georgia and the Caucasus, more broadly. Following the excavations, he conducted an analysis of the cranial materials from the Samtavro cemetery, and, together with an examination of the grave goods, he distinguished two periods. The earlier period he linked to the Bronze Age, as he termed it, the period before the appearance of the Caspians in Media. The later period he identified as the Early Medieval period and he connected it to the Khazars (Bayern, 1872). Bayern then collaborated with Vasil Wiruboff, the head of the Society of Amateurs of Caucasian Archaeology, who dedicated a special Society publication to the Samtavro cranial materials (Wirouboff, 1876). The Deputy Director of the Lyon Museum, Ernest Chantre, also studied these materials, which together with cranial materials collected in other parts of the Caucasus, were published in his monograph (Chantage, 1886). In addition, Rudolf Virchow, a famous German anthropologist and pathologist at that time, through detailed publication of Caucasian materials also made contributions to the development of physical anthropology in the Caucasus (Virchow, 1883). All of the aforementioned scholars were of the opinion that there was no connection between the ancient populations excavated at Samtavro and the modern local populations from the region. This opinion was based on the presence of dolichocephalic (elongated) skulls discovered at the Samtavro cemetery, which were completely different from modern Brachycephalic (broad and short) skulls (Abdushelishvili, 1978).
This position changed in the 1920s, when a new wave of specialists began research in Georgia. Prominent representatives in this new school were Aleksandre Javakhishvili and Giorgi Javakhishvili (no relation). Their research mainly was about the origin of the population inhabiting the territory of modern Georgia. Aleksandre Javakhishvili studied the cranial shape of the modern population of Georgia to determine ethnographic groups and their relation to the world’s population (Bitadze, 2015). He was the first Georgian scholar who studied five Georgian groups (Kakhetians, Imeretians, Gurians, Mingrelians and Rachians) by qualitative and quantitative data combined with the data from different fields of science – Geography, History, Linguistics (Bitadze, 2015). According to his research, ethnographic groups of Georgians (“Kartvelians”) are quite similar and if there are some differences, they are inessential (Bitadze, 2015). Aleksandre Javakhishvili was the first anthropologist who used the term “Kartvelian (Georgian) group” (Javakhishvili, 1960). Later, Malkhaz Abbushelishvili studied the morphology of the skulls from Samtavro cemetery and suggested that the differences in skull shape (dolichocephalic, brachycephalic etc.) between the ancient and modern population of Mtskheta could be linked to the polymorphism of the crania that changed over time (Abdushelishvili, 1978).

A new phase of systematic archaeological investigations of Mtskheta started in 1936 under the auspices of the Niko Marri Institute of Material Culture, Language and History (ENIMKI), directed by Simon Janashia. At this time, burials and baths near Armaziskhevi were excavated (Gamkrelidze, 1991; Giunashvili, 2018). Later, in 1938, archaeological excavations continued at the Samtavro cemetery, where among the notable discoveries was an epitaph in Hebrew, as well as gravestones with the name of the painter-in-chief and architect of Mtskheta, Avreli Akolis, inscribed in Greek (Kalandadze, 1985). In this archaeological campaign, Giorgi Javakhishvili was invited to participate as a physical anthropologist. This was the first time in Georgia that such a specialist was actively involved in archaeological excavations. In addition, Javakhishvili worked on the cranial materials from Samtavro cemetery excavated by Bayern (Phirphilashvili, 1989). Giorgi Javakhishvili is also considered to be the founder of the Biological Station, which was instituted at Batumi in 1926. Later, in 1929, he established the protozoology laboratory at Tbilisi State University (Janashvili, 1987).

Aleksandre Natishvili, who had been the head of the Anatomy Department at Tbilisi State University since 1918, made another important contribution to Georgian biological anthropology. It was Natishvili (1933) who developed the anatomical and histological terminology in the Georgian language. In the 1950s he established the Centre of the
Anthropological Research Laboratory, which today is part of the History and Ethnology Institute at the Ivane Javakhishvili State University. To this day, the Laboratory houses a significant part of the human skeletal materials from Georgian archaeological excavations.

In further intensive archaeological investigations, a royal palace and tombs were discovered at Armaziskhevi, several cemeteries and settlements of different periods were discovered across the whole territory of Greater Mtskheta, and in 1957 Mtskheta became an archaeological reserve (Kalandadze, 1957). In parallel with the archaeological investigations, intensive bio-anthropological investigations were conducted in Mtskheta by Malkhaz Abdushelishvili, who in 1959 replaced Natishvili as the head of the Anthropological Research Laboratory. Abdushelishvili authored a large number of works in the discipline of biological anthropology; he made large-scale analyses not only of materials discovered in Mtskheta, but also from other parts of the Caucasus region, such as from the north Caucasus (Abdushelishvili, 1978, 1980, 1982). During his tenure, the Anthropological Research Laboratory was enriched with human skeletal materials from archaeological sites representing different eras, ranging from the Early Bronze Age to the Medieval period. From the 1960s, biological anthropologists in Georgia were mostly focused on using cranial materials to identify anthropological groups and study the process of anthropogenesis. Postcranial materials were largely neglected and re-interred. It was only in the 1960s that Pavle Pirpilashvili conducted a palaeopathological examination of postcranial materials from the Samtavro cemetery, focusing on ankylosing spondylitis. He focused, however, on individual samples rather than drawing broader conclusions on the health of the Samtavro population (Phirphilashvili, 1989).

In 1974, archaeological and bio-anthropological investigations were undertaken by the Mtskheta Permanent Archaeological expedition, directed by Andrea Apakidze. From this time until the beginning of the year 2000, settlements as well as cemeteries from the Late Bronze-Early Iron Age, the Antique period, and the Early Medieval period were excavated. For example, at the Samtavro cemetery 882 burials were uncovered, dating from the second to the eighth centuries AD (Giunashvili, 2018). The skeletal materials excavated by the Mtskheta Archaeological Expedition were placed in the Mtskheta excavation house. This location served as a repository for the remains and a centre for ongoing bio-anthropological research (Rcheulishvili, 2005). As the result of many decades of archaeological excavations by the Mtskheta permanent archaeological expedition, the Mtskheta excavation house today holds a significant collection of anthropological material (Rcheulishvili, 2005).
In 2008 archaeological excavations were re-launched in Mtskheta through a joint collaboration of the Georgian National Museum and The University of Melbourne, named the Georgian-Australian Investigations in Archaeology (GAIA). One of the objectives of this project was to investigate and systematise skeletal materials discovered in Mtskheta (Sagona et al., 2010a; Sagona et al., 2010b). Dr. Varsha Pilbrow of The University of Melbourne oversaw the research in biological anthropology and supervised several projects, including the present one. It is fitting that the archaeological sites of Mtskheta, which are connected to the first biological anthropological research in Georgia, continue to offer new insights into the next era of biological anthropological research in Georgia.

2.3 Late Bronze-Early Iron Age Caucasus: Pre-state society and rural type settlements

In order to better understand the archaeological context of the Late Bronze-Early Iron Age material, a general description of the Late Bronze-Early Iron Age Caucasus region will provided, followed by discussion of the characteristic features of the Samtavro material culture to which the Late Bronze-Early Iron Age material of this research belongs. This will be followed by more detailed description of the archaeological sites of the Samtavro culture in Greater Mtskheta region.

2.3.1 Overview of the region

Various material cultures are discernible in the Caucasus region dating to the Late Bronze-Early Iron Age (1500-500 BC), differing from each other in components of settlement patterns, burial practices, and/or artefact production. These cultures include the Ior-Alazani culture in eastern Georgia, and the Samtavro culture in the Shida Kartli region in central Georgia (Pitskhelauri, 1973). In other parts of the Caucasus, different material cultures have been observed, such as the Lchashen culture in central and northern Armenia, (Martirosyan, 1964) the Khojali-Gadabay culture, also known as Gandzha-Karabakh in western Azerbaijan, (Ristvet et al., 2012), the Kaiakent-Khorochoi culture in Dagestan and northern Azerbaijan.
(Markovin, 1964), the Colchis culture in western Georgia, Protomeotic culture in the north-western part of the Caucasus (Erlikh, 2007), and the Koban culture in the central part of the northern Caucasus, (Kozenkova, 1996).

Despite variations in material culture in the Late Bronze and Early Iron Ages of the Caucasus, most of these cultures were associated with similar socio-economical changes and upheavals. During this period the establishment of numerous settlements can be observed, pointing to a population explosion. Although the reasons for this demographic change are still unknown, almost all parts of the Caucasus, both in the highlands and lowlands, show evidence of extensive human occupation (Pitskhelauri, 1973; Pitskhelauri, 2005a; Pitskhelauri, 2005b), which are associated with extensive cemeteries, sometimes consisting of 1000 graves, such as Treli in Tbilisi and Samtavro in Mtskheta. Before the Late Bronze Age in the Caucasus region, the dead, particularly the chiefs, were buried individually accompanied by rich funerary artefacts in large earthen mounds called kurgans (Sagona, 2017). Starting from the Late Bronze Age, there is a noticeable transition from rich and individualized collections of grave goods to a standardization of grave types and their contents (Sagona, 2017). Most are small stone graves or earthen pit graves, which do not contain the precious objects belonging to the high-ranked elites. Instead, precious metals and rare stones are replaced by a large quantity of bronze weaponry of different shapes and functions. Almost all male inhumations of this period have daggers, axes, spearheads, or horse bits, suggesting of warrior society in the Late Bronze-Early Iron Age (Castelluccia, 2017).

The Late Bronze - Early Iron Age in the Caucasus is marked by the development of tin and iron metallurgy. In the graves, and ritual places, such as open-air sanctuaries there is an abundance of different type of metal objects. This is associated with an increase in the number of metallurgical workshops and mines, mostly located in the Great Caucasus Mountains, where hundreds of ancient mines are documented, and where copper, antimony and arsenic were extracted (Inanishvili, 2001). Sophisticated technological expertise in mining is demonstrated through two levels with ventilation within the mines (Inanishvili, 2001). The chronology of the introduction of iron in the Caucasus is still debated, with some scholars dating it to the 14th to 13th centuries BC, in the central part of the modern territory of Georgia. However, others associate introduction of iron in this region to the 10th century BC (Abramishvili, 1975). During the Bronze Age, iron objects are very rare, with iron in this period mostly used for decorative purposes, or sometimes for making weapons. By the second quarter of the first millennium BC, however, there was large-scale production of iron objects in the central part of the Caucasus.
region. Among these were tools such as hoes, axes, billhooks, and sickles. The introduction of these iron objects played a significant role in the development of agriculture in the Caucasus region (Sakharova, 2003), so that by the Late Bronze/Early Iron Age, agriculture was one of the main subsistence activities. This is indicated not only by agricultural tools found in settlements and burials, but also by graining tools found close to bread ovens, suggesting that grain production was one of the main activities of Late Bronze-Early Iron Age populations. An important agricultural tool introduced in the Late Bronze-Early Iron Age was the threshing-board. Remains of these are found at settlements as well as in burials, where it was also used for ritual purposes (Ramishvili, 1998). This could indicate that agriculture played not only an important economic, but also a cultural role among the populations of the Caucasus in the Late Bronze–Early Iron Age (Ramishvili, 1998). Alongside agricultural activity, pastoralism still remained one of the main subsistence strategies for the Late Bronze–Early Iron Age populations. At settlements, as well as in burials, a large number of domesticated animals are found, such as cattle, sheep and pigs (Gogadze, 1982). Additionally, in burials as well as in open-air sanctuaries, where people deposited different objects to sacrifice to gods, bronze figures of these domesticated animals have been found, showing their importance for the Late Bronze Age Caucasus populations. At the same time, domestication of the horse had a significant impact not only on military aspects of society but also on the economy. Transportation became easier and faster, in turn intensifying interactions among communities. The domesticated horse was used by pastoralists in livestock mobility and in agricultural activities, as evidenced by the depictions of horses not only attached to military carts but also in yoke (Melikishvili, 1970). One of the hallmarks of the Caucasus in the Late Bronze Age is the introduction of wheel-made pottery. From this period on, there is a large diversity of pottery forms, reflecting the economic activities of the populations. In addition to large storage jars, drinking vessels, and cooking wares, we also have butter churns indicating that dairy products had an important place in the diet of the population (Pitskhelauri, 2005b).
2.3.2 Samtavro culture

Before we describe the Mtskheta region and its archaeological sites that are the focus of this research, a general description of its material culture, including the distribution area, settlements, cemeteries and other characteristic features of the culture is warranted.

As mentioned above, the archaeological culture termed as ‘Samtavro’ occurred during the Late Bronze - Early Iron Age in the central part of the modern territory of Georgia, in the Shida Kartli region. Typical examples of this culture are settlements located near the Kura or Aragvi Rivers at an average altitude of 300–500 m above sea level. Many are located on or around the slopes of natural hills. Some settlements are built on terraces. From Gori to Tbilisi, excavated settlements, with varying degree of detail in their published records, include Kartlaniskhevi, Khovlegora, Natsargora, Samtavro and Treligorebi (Giunashvili, 1979; Gobejishvili, 1951; Kakhutaishvili, 1964; Muskhelishvili, 1978). Some of the characteristic features defining Samtavro as an archaeological culture include dark-grey pottery, often ornamented with so-called zoomorphic handles, a leaf-like bronze dagger, and bronze belts ornamented with engraved zoomorphic and anthropomorphic figures (Tsitlanadze, 2003); (Akhvlediani, 2005; Gomelauri, 2011). Another defining element of this culture is large-sized settlements with houses of rectangular shape with dry stone walls. Within the buildings, ovens were often found in the left corner of rooms, sometimes with additional benches described in the literature as ‘altars’ (Davlianidze & Sadradze, 1989). Examples are the sites of Katlaniskhevi and Natsargora where excavators found sanctuaries within the settlements. These sanctuaries mostly consisted of figures of deities and other sacrificed objects placed in a special place (Gobejishvili, 1951; Khakhutaishvili, 1964).

Agriculture was a significant part of the economy of these sites, as attested by ample remains of grain recovered during excavations. Among the agricultural tools were quern stones used for grinding grains. They were often found close to the bread ovens, suggesting that grain production was one of the main activities of the Samtavro culture. Recent isotopic examination of the material from Treli revealed the presence of millet among the cultivated crops (Herrscher et al., 2014). Bones of both large and small livestock appeared in approximately equal quantities at the sites. In addition, the fact that some buildings had rooms only partly paved with stone may indicate that cattle were sometimes kept indoors (Giunashvili, 1979).

A slight variation on the Samtavro culture is seen in the foothills at elevations of more
than 500 m above sea level. Buildings here were constructed with wattle and daub, the settlements were smaller in area and there was less evidence of agricultural activities as in the Kura valley. One such settlement is Mchadijvari (Dusheti region), located about 700 m above sea level. While the ceramics were similar to that found in the Kura valley, the difference in the size of the settlement, construction techniques, and the scarcity of agricultural tools gives substance to the hypothesis that agriculture was not a main economic activity at this site (Tsitlanadze, 2003). Together with this evidence, less social investment in settlements of the upper elevation zones indicates their seasonal character, typical for pastoralism, and suggests that within the same community in the Late Bronze Age Caucasus, agriculture developed unevenly. The character of subsistence activity varied based on geographical zones. In the fertile Kura valley, agriculture was well developed and was the main subsistence activity, but in the surrounding foothill zone, because of comparatively severe conditions for agriculture, pastoralism remained the major economic activity.

For the Samtavro culture, the dominant grave type is the pit-grave. Sometimes this type of grave might have an earth or stone mound, or even cromlechs. For examples of the Samtavro, Treli and Madnischala cemeteries, see (Abramishvili, 1975; Chubinishvili, 1957; Tushishvili, 1972). Often these cemeteries were attached to settlements, pointing to significant social investment in such places. Cemeteries of this kind are found at Samtavro in Mtskheta, and Treli in Tbilisi, where the settlement and cemetery covers several hectares (Giunashvili, 1979); (Abramishvili, 1975). Besides settlements and cemeteries, one of the characteristic features of the Samtavro culture is hoarding. A hoard is a group of two or more objects intentionally buried in the ground (Lordkipanidze, 2001). It is currently believed that objects found in hoards represent the belongings of a group of people. Needham (1988) calls them “community deposit” and contrasts them with grave contents, which reflect the social character of a single person. Thirteen hoards associated with the Samtavro culture have been recorded, mostly in the mountain and foothill zones (Koridze, 1965). These hoards revealed different types of bronze objects, not only typical for the local Samtavro culture, but also those that are characteristic for the neighbouring region, such as the Colchis culture in Western Georgia. Such finds are considered to be evidence for the interaction between these two cultures (Bedianashvili, 2016).
2.3.3 Samtavro valley and the greater Mtskheta region

The term Samtavro culture comes from the Samtavro valley that is located in the territory of the Greater Mtskheta region. It is considered to be the most striking archaeological site of the whole central part of Georgia during the Late Bronze-Early Iron Age. Below I provide more details of this site, along with other Late Bronze -Early Iron Age sites of the same region such as Narekvavi, Tserovani II and Nichbisiskhevi.

Samtavro Valley is located in the northern part of Mtskheta and is bordered on the east by the Aragvi River, on the west by the Kodman hills, on the south by Monasteriskhevi, and on the north Baitkhevi (Lomtadze, 1974). The Samtavro cemetery was first discovered and studied in 1871, and its investigation became the basis for the formation of archaeology as well as physical anthropology as a discipline in the Caucasus region (Giunashvili, 2018). Samtavro valley contains a multi-layer cemetery, covering almost 1.8 hectare of territory. It existed for almost two millennia, and its earliest graves date to the Middle Bronze Age; however, the majority of the burials date to the Late Bronze Age and later periods (Nikolaishvili, 2005). Overall, 550 Late Bronze–Early Iron Age graves were excavated. The chronology of the central part of the south Caucasus region is largely based on these excavations (Abramishvili, 2003). During the Late Bronze–Early Iron Age, the main burial type is the earthen pit grave with a small-sized earthen or stone mound. Graves are mostly individual, with some exceptions such as grave n. 8, where 33 individuals were found (Nikolaishvili, 2005). While all burials at Samtavro are inhumations, there are also some cenotaphs, wherein no one is buried (Chubinishvili, 1957). Commonly, the deceased were placed in flexed positions, with males mostly laying on their right side and females on their left. All the skeletons were found with the head to the north or west (Chubinishvili, 1957; Kalandadze, 1985; Lomtadze, 1974).

Among the artefacts found in the burials of the Samtavro Late Bronze–Early Iron Age cemetery are different types of ceramic vessels, tools made of bronze and bone, various types of personal adornments, and bronze weapons such as axes, daggers, spearheads, and arrowheads (Chubinishvili, 1957; Kalandadze, 1985).

The settlement, dated to the same period, was excavated on the hill located in the northwestern part of the Samtavro cemetery. The semi-subterranean single-room buildings were constructed with pebbles using mud mortar and were built close to each other along the terraces. for the floors were beaten earth and sometimes, the right half of the room was paved
with flat stones. The roofs were flat and were supported with timber poles. Usually houses in Samtavro had rectangular shaped ovens built with small size slabs and clay on their left sides. Along the back wall there was often a raised platform, believed to have ritual functions, as anthropological clay sculptures were found on these platforms (Giumashvili, 2018). Mostly domestic objects were found in these houses, such as cooking pottery, obsidian sickle blades, iron knives, grinding stones, and clay stamps. The latter took different geometric forms and were often found close to the ovens, and are believed to have been used to stamp bread baked in the ovens (Khakhutaishvili, 1964).

Samtavro valley was not the only Late Bronze–Early Iron Age site in the territory of Mtskheta where a settlement and cemetery are found together. The archaeological site of Narekvavi consists of an almost identical type of settlement and cemetery. It is located 5 km northwest of Mtskheta, on the right bank of the River Narekvavi. The Narekvavi settlement was built along the terraces of seven natural hills. All of these were subterranean rectangular houses with flat roofing. As at Samtavro, rectangular-shaped ovens and ritual platforms were also found at Narekvavi. The material discovered at the Narekvavi settlement is identical to that of Samtavro. To the northeast of the settlement, 43 pit-burials were excavated with almost the same number of burials excavated on the other side of the River Narekvavi. All Narekvavi pit-burials had small stone mounds. The dead were placed in a flexed position, on their left or right side, with the head to the north (Apakidze et al., 1978; Nikolaishvili, 2007).

To the west of Mtskheta, on the lower terrace of the northern slope of the Skhalta ridge where it overlooks the Narekvavi settlement and cemeteries, lies the Tserovani II cemetery. From east to west it is bordered with dry ravines, to the south the Tserovani Plateau, and to the north the Mukhrani Valley. During its excavation, 64 Late Bronze and Early Iron Age pit-burials were discovered (Nikolaishvili, 2005). Late Bronze Age burials were mostly excavated in the central and southern parts of the cemetery, whereas Iron Age burials were found in the north-eastern part and they do not overlap geographically. These burials had both stone and earthen mounds, and also catacomb-type burials. At Tserovani there were both individual as well as group (two or more skeletons) inhumations. The deceased were placed either on their right (mostly male) and left (mostly female) sides in a flexed position with heads oriented to the north. Sacrificial animals were also included in the cemetery, evidenced by the large numbers of domesticated animal bones were found in the burials as well as outside the burials, on the surface. Among the grave goods at Tserovani II cemetery were various types of jewellery, pottery, bronze weapons such as daggers, axes, spearheads, and arrowheads.
indicating to the high social status of individuals placed in this burials (Apakidze et al., 1981).

Burials similar to those found in the Samtavro and Tserovani II cemeteries, were found in the cemetery of Nichbisiskhevi, located 4.5 km west of Samtavro, on the confluence of the Kura and Nichbura Rivers. Overall, at Nichbisiskhevi 116 pit-burials were excavated, among them 72 belonging to the Late Bronze Age (end of the 2nd millennium BC) and 35 to the Early Iron Age (9th - 7th centuries BC) (Rcheulishvili, 2005). All these Late Bronze - Early Iron Age burials were roofed with timber and stone mounds. Some of these burials, especially those belonging to the Late Bronze Age, had stone circles around them. While most burials were individual inhumation, in some there were two skeletons. All were placed in flexed positions, males on the right side and females on the left side. Some burials were damaged by later occupation and it was impossible to determine the position of the skeleton. Remains of timber found under the skeletons suggest that the deceased were buried on a death-bed. Grave goods found in the Nichbisiskhevi burials are similar to those found in the Samtavro and Tserovani II cemeteries, and among them were different types of dark-burnished pottery, personal adornments, and bronze weapons such as daggers and spearheads (Rcheulishvili, 2005).

2.4 Emergence of state society and urbanisation: South Caucasus region in Antique Period

The section below starts with a general description of the region followed by a description of the Iberian kingdom that emerged on the territory that was the Samtavro culture. The characterization of the Iberian kingdom will be provided though the description of the Mtsketa territory, where the capital city of the Iberian kingdom was located. In the final section, the Antique period sites that are the focus of this research (Samtavro, Tsikhedidi, Bargikaria, Tsitsamuri, Nichbisiskhevi, Kamarakhevi, Natakhtari) will be described. The Klde cemetery, located outside of the Greater Mtskheta territory, in the south-western part of the Iberian kingdom will be described as a separate section. The samples from this cemetery are also examinied in this research.
2.4.1 Geopolitical overview of the region

The Antique period (5th BC – 4th AD) in the south Caucasus region is marked by the formation of distinct kingdoms; the Armenian kingdom was located in the southern part of the south Caucasus, the Albanian kingdom was found in the eastern south Caucasus, the Colchian kingdom in the western south Caucasus, and the Iberian kingdom, as the Greeks and Romans called it, was in the central south Caucasus. Based on Georgian literary compendium, Kartlis Tskhovreba (Georgian Chronicles, and translates to “Life of Kartli”), the Iberian kingdom was established in the 4th century BC on the territory associated with what was previously called the Samtavro culture (Kipiani, 2010b; Rapp, 2003). Based on these historical chronicles, the founder of the Iberian kingdom was Pharnavaz. The formation of a state (Iberian kingdom) in eastern Georgia based on written sources is directly connected to the emergence of urbanisation in this region. The capital of the kingdom was Mtskheta, and other cities in this kingdom, which had fortification systems, cultic places, baths, public buildings and palaces (Nikolaishvili, 2005), were mostly situated along the Kura River (Kipiani, 2010b).

2.4.2 The Iberian Kingdom during the Antique period

The 1st century Greek historian and geographer, Strabo, provides a description of Iberian cities, which attests to the well-developed level of urbanisation and architecture of Iberia:

“The greater part of Iberia is so well built up in respect to cities and farmsteads that their roofs are tiled, and their houses as well as their marketplaces and other public buildings are constructed with architectural skill.” (Kaukhchishvili, 1955).

Moreover, a Greek inscription of a grave stone found in Mtskheta dated to the 4th century BC, states that capital city of Iberia had a painter-in-chief and architect (Nikolaishvili, 2005).

The presence of different types of buildings such as palaces, temples and castles in Iberia is an indication of the social stratification of the society (Nikolaishvili, 2005). While graves from the Antique period are generally not characterized by a rich collection of grave goods, there are certain graves that are distinguished by extremely precious funeral artefacts,
such as masterpieces of goldsmithery, which belonged to highly ranked members of society. As described by Strabo, there were four social classes in the Iberian kingdom. The royal family belonged to the first class, together with military commanders and those serving for royal family; priests represented the second class; farmers and soldiers the third class; and slaves comprised the fourth class (Kaukhchishvili, 1955).

The development of a hierarchical state society in the Antique period is directly connected to the development of craft production. Social demand and consumption of prestige goods, which played an important role in the high ranked elite society, determined the nature of craft production (Underhill, 2002). Gold smithing, which was almost unknown in eastern Georgia during the Late Bronze - Early Iron Age, was well developed by the Antique period. Another feature of the Antique period was local production of glass vessels, copied largely from Near Eastern styles (Manjgaladze, 2018).

During the Antique period, the Iberian kingdom was intensively involved in economic interactions with the Roman and Persian worlds. This is indicated by various imported artefacts found in the graves. In addition, there were dramatic changes in burial practice during the Antique period. Pit-burials become less prevalent and were only typical of the lower-class population and in contrast to the previous period, these pit-burials were roofed with stone slabs. During the Antique period the main burial types include stone cists, jar-burials, and tile-burials.

The abundance of weapons that characterised the Late Bronze-Early Iron Age burials were substituted in the Antique period for personal adornments, often made of gold and silver (Apakidze, 1980). Moreover, there were changes to pottery production, with forms and their decoration becoming more diverse. As opposed to Late Bronze Age, when pottery production was part of the household activities, in the Antique period pottery was produced in dedicated pottery workshops. One noticeable novelty in terms of pottery production during the Antique period was the large-sized *pithoi*, which were often found near fortified places, temples or palaces. These were placed in the ground and are considered to have been used for wine storage (Nikolaishvili, 2012).

Agriculture in the Antique period was also changing, with tools used for agricultural purposes becoming more advanced, making it possible to farm larger and more diverse terrain. A majority of tools were made from iron and there is also evidence of plough use, which was only slightly evident in the previous time period (Jalabadze, 1960).
2.4.3 Greater Mtskheta in the Antique Period

The modern territory of Greater Mtskheta is defined to the east by the Zahesi railway station, to the west by the village of Dzegvi (as well as sites of Khekordzulakhevi and Nastakisi), to the north by Mukhranis Sanakhebi, and to the south by the Satkepela-Didgori range (Nikolaishvili, 2005). Two main environmental factors are considered to be the basis for the development of urbanisation in Mtskheta. The first is its raised location, which creates a natural protection for Mtskheta and allows for control over the surrounding areas. The second element is the number of rivers and their confluences, which provided “natural sanitation” for the city (Kipiani, 2010a, 2010b; Vitruvii, 1936). Based on Georgian mythology, the city of Mtskheta was established during the 6th-4th centuries BC by Mtskhetos, son of the legendary Kartlos (Berdzenishvili, 1964). The city was initially called Kartli, after the mountain where the city was located. In the 4th century during the reign of Parnavaz, founder of the Iberian kingdom, the city was called Armazi after the idol that Parnavaz erected in the city.

During that time (4th century BC), as noted in the Georgian historical chronicles, the city of Old Mtskheta was located only on the right bank of the Kura River in Armaziskhevi (Kavtaradze, 2012). The construction of the city on the left bank of the Kura (where modern Mtskheta is located) was started by the eighth king of the Parnazav dynasty, Bratman (143-123 BC). It was completed by the eleventh king of the Parnazav dynasty, Rok (2-53 BC). By that time (around 60 BC), Mtskheta consisted of two independent cities, divided by the Kura Rives. Each had its own king, in the period known as the diarchy (Kipiani, 2010b). During the diarchy, the King reigning in Mtskheta, the city on the left bank of the Kura, had superiority over the king of Armazistsikhe, reigning on the right bank (Kipiani, 2010b). Based on the Georgian historical chronicles (Kaukhchishvili, 1955) there were several quarters in Mtskheta, including Sarkine, Tsikhe Didi, Zanavi and the Uriata quarter (Nikolaishvili, 2005). Apart from a local chronicle (Kaukhchishvili, 1955), the Antique period Mtskheta as an urbinized area is described by Pliny the Elder (23-79 AD) as a place of Meskhetians – Moschorum Tractus (Nikolaishvili, 2005). In the 2nd century AD, the city of Mtskheta is mentioned by the Greco-Roman geographer, Claudius Ptolemy (Ptolemy, 1901).

Numerous archaeological excavations were conducted in Greater Mtskheta from 1889 to 2015, revealing the Iberian royal residence, also called Armazistsikhe (Armazi castle) or Bagineti, in the site of Armazi on the right side of the Kura River. It is dated from the 4th BC to 5th centuries AD. In addition, a fortification system, Roman-style baths, tombs and a sarcophagus were discovered (Nikolaishvili, 2012). More can be learned about the Iberian
Royal residence from the three examples of epigraphy found in Mtskheta. These inscriptions also provide information on the kings’ names and other titles in the Iberian kingdom (Nikolaishvili, 2005).

One of the indications that Mtskheta population in Antique period was highly heirarchazed society is the inscriptions found at Armazistsikhe-Bagineti, close to the Roman baths, the epitropos and tutor of the king, Anagranes, is mentioned. He built the baths for the daughter of the Armenian king, Vologez, and wife of Iberian king, Amazasp, (Nikolaishvili, 2005). Apart from the Royal palace and baths, a temple with six apses, a winery, a two-celled building, Late Roman period buildings, and a rock-cut sarcophagus dated to the 2nd-3rd centuries AD were excavated. Among the grave goods were silver vessels, including one with an Aramaic inscription, and another depicted the Roman emperor Markus Aurelius. Also included with the grave goods was golden jewellery ornamented with precious stones (Nikolaishvili, 2012).

In Antique and Early Mediavl period, on the left bank of Kura River, the city of Mtskheta was located between the confluence of the Kura and Aragvi Rivers. The whole city was enclosed within a wall, which ran along the right bank of the Aragvi River and Monasteriskhevi, crossed the Mtskheta hills, and down to the Kura River. The city wall encircled about 50 hectares. Archaeological excavations revealed the city wall to be 6 m wide, the foundation built with stones and the upper part with adobe (Nikolaishvili, 2005). Mtskheta had two main gates, one from the north at Monastriskhevi, and the other from the south-west on the Kura River (Nikolaishvili, 2005) (Figure 2). An inscription dated to 75 AD was found near the southern part of the city wall, describing how Emperor Augustus helped the Iberian King Mitridate to construct the fortification of the city (Javakhishvili, 1960).

All above described evidences suggest that in Antique period Mtskheta as well-built, densely populated urban area resumbling Roman style city. During this period many important historical events are connected to Mtskheta, that probabaly influenced its population’s socio-economical condition. In 65 BC Gnaeus Pompey Magnus conquered the Iberian kingdom, the king of Iberia, Artoki, burned the bridge and escaped from Armazi to the other side of the Kura River. Beyond the Romans, during the Antique period, Mtskheta was also the battlefield for the war against the Persians. In the 2nd century AD, during the reign of Pharsman, Mtskheta was besieged by the Persians (Kaukhchishvili, 1955).
The urban life of Mtskheta during the Antique period is illustrated by fragments of friezes and antefixes found in the remains of Roman baths at the site Svetitskhoveli, located on the left bank of the Kura River (Nikolaishvili, 2005). Burials dated to the 3rd-4th centuries AD were also excavated in this area. Among these burials, 11 were stone cists, 5 were made of ceramic slabs, 3 were tile-graves, and two were pit-burials roofed with stone slabs. A particular

Figure 2. Reconstruction of ancient Mtskheta based on archaeological sites (Nikolaishvili, 2005)
stone cist burial (#25), which belonged to a noble female individual buried in an extended position, contained a large number of precious personal ornaments, such as finger-rings, pendants and beads. In this same burial was a golden coin depicting the Persian king Ardashir I (226-242 AD) (Apakidze et al., 1989). As in the earlier Late Bronze-Early Iron Age, the Samtavro cemetery remained the largest of the cemeteries in the Mtskheta region during the Antique period. Samtavro’s Antique period burials are built on top of the earlier burials. While, several burial types can be distinguished, the most common was the jar-burial, with over 150 of this burial type excavated at Samtavro. They were placed in the ground, mostly horizontally, aligned on S-N axis, and usually contained a single individual. All individuals were placed in the flexed position, depending on gender laying either on the right (male) or left (female) side. Grave goods in the jar-graves mostly included small-sized ceramic vessels, ear-rings, bracelets, and Iranian coins dated to the 1st centuries BC (Tolordava, 1980). Pit-burials roofed with slabs, stone-cists, tile-burials, clay sarcophagi, clay slabs, and bricks were also common Antique period burial types and sometimes contained rich grave goods, such as stone cist #597, which is distinguished by a large number of precious objects made of gold and silver. However, for many Samtavro burials, poor grave goods were also typical, suggesting there was distinct social stratification of Mtskheta’s society during the Antique period (Rcheulishvili, 2005), and individuals belonging to different social levels were buried at Samtavro, with the exception of the Royal family (Apakidze, 1980).

Archaeological materials providing information on the urban life of Mtskheta were discovered in one of the quarters of Antique-period Mtskheta–Tsikhedidi. This site is located in the north-western part of the Greater Mtskheta’s territory, on the left bank of the Tsikhedids khevi River, one of the confluences of the Kura River. In this part of the city, remains of Antique-period large-sized stone walls were excavated. Next to these, three pit-burials and four cist graves of the same period were discovered (Apakidze et al., 1955). In the same area, Late Antique buildings were excavated at Bargikaria. These buildings were built with cobble pebble, and the floor was paved with flat stones. Not far from these buildings, storage pits filled with pottery fragments and animal bones were excavated. Next to the storage pits, one tile-burial and two pit-burials were found. In these inhumations, red-coloured pottery typical for the Antique period as well as beads and a pendant were discovered. A cist tomb containing two individuals placed in a flexed position, on their right side was excavated. The deceased were accompanied with pottery pendants, iron arrowheads, and different types of beads. Among
these grave goods was a silver coin of the Parthian king Orodes I (57-38/37 BC) (Apakidze et al., 1986).

Written sources indicate that apart from Armazistsikhe (located on the right bank of Kura River) and Mtskheta (located between the Kura and Aragvi Rivers), there was another city in the territory of Greater Mtskheta. Strabo describes a city called Sevsamora, and archaeological excavations conducted in Tsitsamuri, located east of Mtskheta and on the left bank of the Aragvi River, revealed the remains of an Antique-period city (Apakidze, 1959) that may be Sevsamora. Apart from a fortification system, circular-shaped sandstone buildings with red slip roof tiles were found. Pit- and jar-burials dated to the 1st -3rd centuries AD were also found with a large amount of pottery, items of personal adornment, as well as perfume bottles and coins, both Parthian and Roman. These finds suggest that Sevsamora was equally rich as Armazistsikhe (Nikolaishvili, 1995). Other site that can be associated with Sevsamora is on the right bank of Aragvi River, pit-burials covered with small size earth mounds, and cist-tombs were discovered at Early Antique period Kamarakhevi cemetery. Burials were single inhumations, and individuals were placed in a flexed position, males placed on the right side and female individuals on the left side. Among the grave goods were various types of pottery, personal adornment, and weapons such as a sword, spearhead, and knives (Ramishvili, 1959).

Apart from archaeological sites located in the urban areas of the Great Mtskheta’s territory, Antique period sites situated on the periphery of Great Mtskheta were also excavated. Among those sites are Nichbisiskhevi, where, besides a Late Bronze-Iron Age cemetery (described above), a Late Antique period settlement and pit-burials were excavated. Another site, Natakhtari, is located in the northern part of the Greater Mtskheta region. As with Nichbisiskhevi, Antique period burials were situated next to the Late Bronze Age settlement and cemetery. In the Antique period at Natakhtari, skeletons were buried in an extended position, and grave goods included different types of pottery, and a silver coin of the Roman Imperator Augustus (Rcheulishvili, 2005).

Above mentioned archaeological discoveries fit very well with the historical evidence, suggesting a flourishing urban life in Mtskhta that had both Roman and Persian cultural influence, but at the same time maintaining its own strong cultural features typical for the Iberian kingdom and central part of the south Caucasus.
2.4.4 South – Western Part of the Iberian kingdom

During the Antique period in the Iberian kingdom, in addition to Mtskheta, there were other urban settlements located along the Kura River. Among them is Odzkhe, which, based on the Georgian historical chronicles (Kaukhchishvili, 1955), was founded in the 3rd century BC. It was the centre of the Samtskhe-Javakheti region of the Iberian kingdom and at times the winter residence of Iberian kings (Muskhelishvili, 1977). The Samtskhe-Javakheti region and upper Kura basin was one of the main gateways through the Caucasus region, connecting with the Near Eastern region as well as linking the eastern Caucasus to the western part bordering the Black Sea (Chilashvili, 1968) and thus it was an important economic corridor during the Antique period. However, the scarcity of archaeological evidence makes it impossible to comment about the urban life of this region during the Antique period.

One of the interesting Antique period archaeological sites in the upper Kura basin is – the Klde settlement and cemetery located near Akhaltsikhe, between the confluence of the Kura and Potkhvi Rivers, covering 3486 square metres (Gambashidze, 2006). Structures at Klde were built with cobble stone and roofed with tiles, and domestic hearths were often found in the buildings. Although the Klde settlement was rebuilt several times (Antique and Early Medieval period), its main parts were built in the 1st century BC. Attributed to the same period are the majority of burials excavated at its cemetery. There are mainly two types of burials here, stone-lined pit-burials and jar-burials. Burial types and artefacts including a Roman lamp, a Parthian silver coin, ornamented glass intaglios, and terracotta figurines (Gambashidze, 2006), are very similar to those found in Mtskheta. As it was for the Greater Mtskheta region, in the south-western part of the Iberian kingdom, there is a strong Roman and Persian cultural influence reflected mostly in burial rites.

2.5 Apex of the development of urbanisation: South Caucasus region in Early Medieval period

In this section, I have provided a brief review of the region and a description of the Iberian kingdom in early Medieval period, when Mtskheta was an apex of the development of urbanisation. This will be followed by the characterization of the Capital city of the kingdom -
Mtskheta. It will also comprise the description of the archaeological sites included in this study. These sites are Samtavro, Martaziskhevi and Tsilkani cemeteries all located in the territory of the Greater Mtskheta.

2.5.1 Geopolitical overview of the region

The Early Medieval period (4th-6th centuries AD) in the Caucasus region is marked with important socio-economic and political changes. There was an increase in the political influence of the Sasanian Persian Empire. This resulted in the decline of the royal reigns in all three kingdoms (Albanian, Armenia and the Iberian). At the same time there is still strong Roman cultural influence which can be seen in the introduction of Christianity as the state religion in the Iberian kingdom. The whole Early Medieval period in the south Caucasus was marked by the long war between Sasanian and Byzantine empires that took place during various interludes in different parts of the south Caucasus.

2.5.2 The Iberian Kingdom in the Early Medieval period

Based on written sources, the fall of the Kartli reign is dated to the 6th century AD and is associated with prolonged resistance against the Persian kingdom, which finally ended with the abdication of local royalty in Iberia (Melikishvili, 1970). After the abdication, local lords called Eristavi (equivalent to duke, or a governor of a province) became more powerful. These political changes, together with the emergence of strong lordships and the collapse of centralized society, resulted in a transformation in the previous social order to one that was much more stratified. For example, a Georgian hagiography written in the 5th century AD, refers to an upper class nobleman, which also implies the existence of lower class noblemen (Melikishvili, 1970).

Despite certain socio-economical-political changes from the Antique to Early Medieval period, no radical changes in terms of subsistence activity and population movement occurred in the Kartli region. For example, archaeological excavations in Eastern Georgia suggests that
Early Medieval villages built on top of Antique period layers, demonstrate a smooth continuation in terms of architecture and material culture (Ramishvili, 2008).

At the beginning of the Early Medieval period, eastern Georgia saw many urban changes. First, in the 5th century before the end of the Iberian kingdom, the capital city of Iberia was moved from Mtskheta to Tbilisi by king Vakhtang Gorgasali. Related to this is the establishment of other cities such as Ujarma, located east of Tbilisi. In addition, old urban areas in eastern Georgia, such as Kaspi and Urbnisi, continued to grow (Kipiani, 2010b). Most of these sites were located along the Kura River and were not only cultural but also economic centres of the Iberian kingdom.

During this period the Iberian kingdom was often disturbed by warfare. In addition to the invasion by Persia, other sources of military conflict arose with Byzantium and with nomads raiding from the north Caucasus. In 542-562 AD, a long, large-scale war between the Persian and Byzantine Empires, over control of the western part of the south Caucasus, most likely had significant economic influences on the population in Georgia (Melikishvili, 1970).

The socio-economic changes engendered as a result of the numerous conflicts during the Early Medieval period were reflected in burial rites. An additional influence is likely to have been the introduction of Christianity. Based on the Georgian Chornicles, Chirstianity in Georgia was brought by St. Nino from Cabadocia (central Anatolia), and was introduced as a state religious by the Iberian king, Mirian II, in 337 AD. (Kaukhchishvili, 1955). The graves from this period are not characterized by rich burial goods, and people were no longer buried in flexed positions (see the description of Samtavro burials), as was dominant in previous period, but were buried in extended supine positions, consistent with Christian traditions and culture.

Although archaeological evidences suggest that from Antique period to Early Medieval Period there is a smooth transition in term of subsistence activites, written sourses indicate that the Early Medieval period is characterized by the intensification of agricultural activities, mainly connected to the introduction of irrigation. The historic chronicles (Kaukhchishvili, 1955) indicate that in Rustavi (south - east of Tbilisi), by the end of the 4th century AD, an irrigation system was constructed by King Trdate. The same source indicates that other irrigation systems were constructed in the other parts of the Iberian kingdom in 5th and 6th century AD (Berdzenishvili, 1964). Despite the growing agricultural activities, pastoralism still remained one of the important subsistent activities (Javakhishvili, 1960).
2.5.3 The Greater Mtskheta in Early Medieval period

Already by the end of the Antique period and the beginning of Early Medieval period (4th-6th centuries AD), Mtskheta was a densely populated, well planned urban settlement. Archaeological excavations near the Svetitskhoveli Cathedral revealed paved streets and rectangular houses with additional structures - presumably storages. The lower parts of these houses were built with cobblestones, whereas the upper parts were constructed with adobe, and tiles were used for roofing. These buildings are dated to the 4th-6th centuries BC (Apakidze & Nikolaishvili, 1987). Similar houses, covering 400 sq. m. were uncovered on the left bank of the Kura River, as well as in the central part of the town on the territory of the park, which extended 300 sq. m. (Nikolaishvili, 2005).

Remains of a palace, were excavated on the right bank of the Kura River, in Armaziskhevi. It is located about 10 km north from the Iberian royal residence - Bagineti. In this area, cornice details, a column base and a capital were found. Associated with the palace is a winery that contained 50 wine storage jars. The Armaziskhevi palace is attributed to the pitiakhsh - the head of the province in the Early Medieval period (Nikolaishvili, 2005).

Early Medieval period castles were also constructed in Mtskheta. One such castle is Bebristisikhe/Beltistsikhe, situated in the northern part of Mtskheta, and originally controlling the entrance from the north (Nikolaishvili, 2005).

As was mentioned above, Georgian historical chronicles suggests that the Early Medieval period in Eastern Georgia was period of intensive warfare. During this time Mtskheta was the scene of various battles that presumably would effected its populations socio-economic life.

By the end of the Antique period and the beginning of Early Medieval period, the Iberian Kingdom experienced intensive Alan military raids from the north Caucasus. Based on written sources, one such Alan invasion ended with a battle at Mtskheta, where the Iberian king Amazasp defeated the Alan army (Kaukhchishvili, 1955). Mtskheta was probably one of the important locations for the Persian army during the war between Persia and Byzantium that took place in western Georgia in 542-562 AD. In 554 AD, the head of the Persian army, Mermeroe, was wounded during the battle against Byzantium and he died in Mtskheta (Javakhishvili, 1960).
Although in the 5th century the capital of the Iberian kingdom was moved from Mtskheta to Tbilisi, Mtskheta still remained an important settlement. With the introduction of Christianity as a state religion of the Iberian kingdom, Mtskheta became an important religious centre, as the main cathedral, Svetitskhoveli, which also acted as the residency of the patriarch (Javakhishvili, 1960), was constructed there. It was only in 735-736 AD, with the Arab invasion, led by a commander known in Georgia as Murvan the Deaf, that Mtskheta was destroyed. After this time Mtskheta was not mentioned in written sources as a town and for a long period it remained unpopulated (Gioladze, 1991).

In the early Medieval period, the Samtavro cemetery still remained one of the main cemeteries of Mtskheta up until the Arab invasion. Compared to the previous period, there were slight changes in terms of burial practice and architecture. The main burial types are stone cist, and pit burials roofed with slabs. Most of these Early Medieval burials are cut into the Late Bronze–Early Iron Age settlements. Starting from the Early Medieval period, individuals were increasingly buried in the extended position, though at Samtavro in the Early Medieval burials, the majority of skeletons were found in the flexed position. One of the novelties of burial practice in the Early Medieval period was the appearance of a large number of individuals within a tomb. Skeletons were often placed with the head to the north, considered to be a Christian tradition (Apakidze et al., 1981). Burial goods are not as rich as in the previous period, and in some cases, burials are without any artefacts, which is very characteristic for the Christian tradition. Among the burial goods found in the Early Medieval period at Samtavro are mostly personal adornments such as bronze pins, fibulae, necklaces, bracelets and finger rings. (Apakidze et al., 1981).

One of the interesting Early Medieval burial sites located in the territory of Greater Mtskheta is Matraziskhevi, which is situated on the right bank of the Kura River. In this territory, the first Early Medieval burials were discovered in 1905. In this burials, individuals were placed in the extended position. Later, in 1951, two 4th century stone cist tombs with three individuals placed also in the extended position were excavated. Burial artefacts included two glass perfume bottles, beads, and bronze fibulae (Saginashvili, 1967). In 1967 and 1969, another 37 stone cists were excavated. Most of these were family tombs, where skeletons were buried in extended positions. Based on the grave goods such as glass perfume bottles, beads and bronze pins, these burials were dated to the 4th-7th centuries BC (Ugrelidze & Amiranashvili, 1969). Besides the burials at Martaziskhevi, the remains of a settlement from
the same period were excavated. It was comprised of dwellings, storage buildings, ovens, and large ceramic jars presumably for wine storage placed in the ground.

In terms of burial architecture, completely different Early Medieval inhumations dated to the 4th-5th centuries AD were found in Tsilkani (Nikolaishvili, 2005), located north of Mtskheta on the left bank of Narekvavi River. The tomb had a rectangular shape and was placed underground, aligned along the E-W axis. The tomb was built with well dressed sandstones using mortar. From outside it was surrounded by a wall of three rows of river stone. The tomb consisted of a main hall with a semi-circular arc measuring 3.45 x 3.25 m, and a dromos (entrance). The entrance of the tomb was from the east with 13 steps going down the corridor. In the main hall, along the wall on benches were eight skeletons in extended supine positions. The heads of the skeletons were toward the west and were wrapped in cloth. Unfortunately, the tomb was disturbed and looted prior to the excavation. On the walls, the depiction of crosses was preserved, and also Greek inscription in red and black—

“I, Tikas and the monk, my Abba Pharanuses, constructed this sepulchre from hewn stones for us. Papriupas (?) Isdigerdes (?) also rest here besides...”
(Kaukhchishvili, 1982).

Next to the tomb were pit burials and stone cists, where the dead were buried in the Christian tradition: in an extended supine position, laying on a clay deathbed. Three metres west of the tomb are the remains of a church and a drystone wall enclosure (Nikolaishvili, 2005). Tsilkani burial architecture suggests that individuals buried there belonged to the upper social class and already in this period (4th-5th centuries AD) Christian traditions in the Iberian kingdom is widespread.

Summary

The emergence of urbanisation in the Caucasus region was not an abrupt process. The Late Bronze/Early Iron Age in the Caucasus region that preceded urbanisation was already characterized by a general increase in population and the appearance of large settlements where subsistence activities included both pastoralism and agriculture. The subsequent emergence of urbanisation was the result of a gradual development, directly connected to the appearance of
the Iberian kingdom in the central southern part of Georgia. The formation of a state society in the Caucasus region was initiated in the Late Bronze-Early Iron Age and the appearance of large building and settlements is believed to be an expression of power and social status of the elite (Smith et al., 2004). The subsequent development of agriculture and general increases in the economy due to population increases, together with establishment of a state society that started in the Late Bronze/Early Iron Age can be considered as the main drivers of urbanisation in the following Antique period. It is likely that this process was accompanied by the migration of populations from rural places to the capital, which resulted in denser populations at Mtskheta and thus a diversification of subsistence activities. The development of trade and craft specializations typical in urban societies such as goldsmith, glass production, metalworking and others, made the economy of ancient Mtskheta society more diverse and the dependent only on agriculture and pastoralism was less then in previous period. The emergence of state society and the formation of the Iberian kingdom can be considered the main reason for the increased hierarchical stratification of the Greater Mtskheta population. Based on the archaeological discoveries described above, the population was divided into different social groups presumably with varying access to food and living conditions. This process of social stratification intensified later in Early Middle Ages, when the Iberian kingdom became more centralized.

This description of the archaeological context provided in this chapter will assist to formulate the hypotheses of this research, which will be given in the final section of this chapter. Although bio-anthropological studies on the skeletal material from the Greater Mtskheta region has been undertaken, it has mostly focused on the cranial material. No sufficient palaeopathological investigations were conducted to understand the health conditions of the ancient population of Mtskheta. This provides the possibility to study the health conditions of the populations from each period described in this chapter.

It can be expected that the socio-economic processes, described in this chapter such as shift from rural Samtavro settlement to densely populated urban centre that is linked to the poor sanitary conditions; social hierachization of society and intensification of warefare, directly affected the health of the people. Apart from it, an intensification of trade and craft specializations that is associated to urbanisation, would diversify the population’s diet and make it less dependant only on agricultural or pastoral products.
2.6 Hypothesis

From the review of the events and published information from the excavations in Mtskheta, I hypothesised that the increased urbanisation that occurred from the Late Bronze/Early Iron Age (15th-6th centuries BC) through the Antique period (5th century BC - 4th century AD) to the Early Middle Ages (4th - 6th centuries AD) led to changes in diet and had profound effects on the health of the residents in the Greater Mtskheta region. In particular, the transition from the Late Bronze/Early Iron Age to the Antique period likely led to dramatic changes in diet with the evidence for a shift from a hunter-gatherer to an agricultural subsistence. As a consequence of those shifts, we expect to see deterioration of oral health (shift from hunter gatherers to sedentary – urban lifestyle) (Hillson, 2001) and appearance of bacterial and viral infections on a bigger scale (shift from Late Bronze Age to Antique Period) (Armelagos, 2009; Greger, 2007).

In addition, the period from the Antique to the Medieval was characterised by increased social stratification but also by increased military conflicts, which likely would have had adverse impacts on the health of the population, particularly the lower echelons of society.

Finally, various studies have suggested that urbanisation per se can affect the health of urban residents due to the increased exposure to diseases and, particularly during early stages of urbanisation, poor sanitation and living conditions.

The Greater Mtskheta region in Georgia, provides a unique opportunity to examine the effect of urbanisation on the population health during these three periods. The availability of well characterised skeletal remains, associated with distinct cultural practices, from distinct regions allows for comparisons to be made from individuals from different strata of society and for comparisons to be made across different urban or rural locations, during these three periods.

The overall hypothesis is that urbanisation, with consequent effects on agriculture, had detrimental effects on the health of populations in the Mtskheta region. Given that the changes in urbanisation in Mtskheta started in the Late Bronze/Early Iron Age, progressed gradually into the Antique period and extended into the Medieval period, it is likely that the effects on population health may also have progressed gradually. However, some transitions in diet (e.g. the shift from hunter gatherer to agriculture) may be associated with more dramatic shifts in health.
To investigate this hypothesis, this thesis examines porotic lesions and dental pathologies (caries, periapical lesions, ante mortem tooth loss, calculus) on skeletal remains excavated from the Greater Mtskheta in the three historical periods (Late Bronze/Early Iron Age, Antique and medieval periods) as distinct aims:

1. To examine and compare the prevalence of porotic hyperostosis in the skulls of skeletal remains from 13 Greater Mtskheta burial sites. Porotic hyperostosis is a common feature of skeletal remains from various archaeological sites and is a surrogate marker for general health and anaemia in particular (Bothwell, 1995; Ortner, 2003).

2. To examine and compare the prevalence of caries in teeth 13 Greater Mtskheta burial sites. The presence of caries can be used as a marker for general health but may also be associated with changes in diet (Lanfranco, 2012). In particular changes to a carbohydrate-rich diet, associated with the emergence of agriculture, has been implicated in increasing the incidence of caries (Larsen, 1997).

3. To investigate the oral microbiome present in dental calculus from teeth excavated 13 Greater Mtskheta burial sites. Using ancient DNA techniques, I aim to identify distinct bacterial species in the biofilm of dental plaque as measure of diet and general health (Weyrich, 2017).

1) The impact of urbanisation on the population’s health condition was not abrupt, but rather it was a long and slow process.

Urbanisation that is associated with population density and poor sanitation as well as the occurrence of social hierarchization is responsible for the creation of poor living conditions, which can result in the augmentation of different infectious diseases. As we saw in the review of the historical and archaeological context of Mtskheta, the formation of a complex society, which started in the Late Bronze/Early Iron Age and which progressed into the Antique period resulted in state formation and urbanisation that was gradual. As such, we should not expect an abrupt increase of pathologies from the Late Bronze/Early Iron Age to Early Medieval period.

2) With the emergence of urbanisation, the diet of the population changed gradually.

It has been argued that the development of urbanisation and the economy are interconnected (Davis and Henderson, 2003). During the process of urbanisation, the economy
becomes more complex and diverse. Compared to the pre-urbanised period, the urbanised economy does not depend strictly on agriculture or pastoralism. Urban society is much more involved in interregional trade, where different types of goods are exchanged. Moreover, urbanisation introduces new occupational specializations, such as craft specialization or the service industry (Kolko, 2010) and this is evidenced by the presence of rich burial items in Mtskheta in Antique and Early Mediaeval period. It is proposed that in Mtskheta, changes in subsistence activities diversified the population and made it less dependent on agricultural products such as grain. If so then this might be reflected by a decrease of caries among the population as grain rich in hydro-carbonates is responsible for dental caries.

This research studies the impact of urbanisation on the Greater Mtskheta population focusing on a change in health conditions and diet in terms of living conditions and access to food. All these elements are generally characteristic for urbanisation. However, in different parts of the world the degree of impact of urbanisation varies. In Greater Mtskheta during the Late Bronze Age, Samtavro was a village-style culture already had large settlements with developed agriculture and pastoralism. During the Antique period, Mtskheta became a typical Roman-type city trade, with large dense population which was involved in interregional trade and developed craft specialization, and with a stratified society. The transition from a village-style culture to urbanised society was a long process, and as a result the negative affect of urbanisation on the population was gradual. The same process is supposed to have occurred from the Antique to Early Middle Ages, when the Iberian kingdom became more centralized and social stratification became more pronounced.
Chapter III: Methods and Materials

In order to understand the results of this thesis, it is important to describe how and from where the data were collected, the volume of skeletal material, and the methods of statistical examination used. In this chapter, I provide information about the location of the archaeological sites and storage conditions of the materials in Georgia, how the materials were collected and what criteria were used for including or excluding samples for study. All the skeletal material collected date from the Late Bronze Age, Antique, and Early Medieval periods and were excavated in Greater Mtskheta region. This will be followed by a description of the methodology used for sex determination, the indicators of health conditions of pre-urban and urban populations and how these conditions were recorded and analysed statistically.

3.1 Locations and storage conditions of the anthropological materials

The Georgian Anthropological collection is the largest anthropological collection in the Caucasus region. The collection in Georgia has been divided into three parts and now it is stored at three different locations.

The main part of the collection was moved recently from the original Mtskheta excavation house located in the centre of the town to the Armazi excavation house outside of Mtskheta. The Mtskheta excavation house, previously known as the Mtskheta Archaeology Institute, was the centre used by all archaeological groups working in the Mtskheta region (42 archaeological sites of various time periods), until its demolition in 2017. It was where the Anthropological collection (cranial and postcranial materials) was first housed and was also the site of the Anthropological Laboratory. Before the 1960’s all postcranial materials were generally neglected and reburied, as the archaeologists and anthropologists did not consider those materials as valuable sources for further study. So, the collection from earlier excavations (1930-1960) consisted of mostly cranial materials. When Andria Apakidze became the director of the Mtskheta archaeological excavations in 1967, he established new rules whereby all anthropological materials (cranial and postcranial) found in the burials were to be collected and nothing was to be left or reburied. He also stipulated that only anthropologists (not
archaeologists as occurred previously) be permitted to excavate osteological materials (humans, domesticated animals). As a result, archaeologists started working along with anthropologists in the field (personal communication with the anthropologists Mzia Rcheulishvili, Nana Kiladze). A. Apakidze was the first archaeologist to start collecting whole skeletal materials (cranial and postcranial) in the belief that these would provide a very valuable source for anthropological studies (personal communication Mzia Rcheulishvili, Nana Kiladze). During his tenure as director, he created the anthropological collections and the Anthropological Laboratory, housed at the Mtskheta excavation house. By restricting the housing of all anthropological materials excavated at Mtskheta region to the Mtskheta Archaeology house he nullified the previous practice of anthropologists removing these materials Mtskheta to different institutions.

It was at the Mtskheta excavation house where the joint Georgian-Australian Investigation in Archaeology (GAIA) expedition directed by Prof. Antonio Sagona was initiated in 2008 and analyses of these materials continues to this day (Sagona et al., 2010a; Sagona et al., 2010b). This project focused not only on new excavations but on investigations of old and previously excavated materials in order to provide a more complete anthropological picture of the whole area. GAIA was a multidisciplinary project, involving scientists from various fields, including my supervisor, Dr Varsha Pilbrow. My PhD is a result and part of the GAIA project.

The second location of the Georgian Anthropological collection is at the Georgian National Museum, where cranial materials from predominantly earlier excavations (1930-1940) and all the skeletal materials from recent excavations from all over the country are stored.

The third location of the Georgian Anthropological materials is at the Laboratory of Anthropological Research in the Institute of History and Ethnography at Tbilisi State University, which contains cranial materials from early Mtskheta excavations (1930-1960). This collection was curated and studied by the head of the department of Anthropology, Professor Malkhaz Abdushelishvili and also by Giorgi Djavakhishvili and Pavle Pirpilashvili.
3.2 Storage conditions of the materials

The collection at the Mtskheta excavation house was for the most part carefully labelled, reconstructed (glued if bones were damaged) and kept on special shelves. However, some materials that couldn’t be reconstructed (was not possible to glue and put them together) were labelled and kept in separate boxes. As the collection pre-dated digital technology, all the information about burial, time period, excavation date, head of the excavations, sex and age, and bone/skeleton description was originally written in laboratory notebooks. This was further complicated by the fact that in the 1990s, Mtskheta excavation house ceased operations, as did others in the country, due to the political upheavals in Georgia. Archaeological excavations and research at the Mtskheta Archaeology Institute stopped and the building, with its collection, was abandoned. Fortunately, three archaeologists (Gela Giunashvili, Giorgi Mandjgaladze, Vakhtang Nikolaishvili) maintained the house and the collection, saving it from significant damage or theft during this time.

The anthropological materials have now been digitised and labelled according to international standards. All the specimens have been cleaned and are kept in individual, marked boxes. It should be noted that all the skulls from the old excavations (both reconstructed and not reconstructed osteological materials) were commonly covered with shellac, which was the preferred conservation method by anthropologists at that time.

3.3 Preparation for field work

Before going in field, I trialled my methodology using the osteological materials from the Pilbrow laboratory of the University of Melbourne and I undertook an interobserver error study with an experienced researcher, which helped to confirm my data collection protocols. All data were entered onto datasheets according to “Standards” and was based on trial analysis of the skeletal materials from Pilbrow lab.
3.4 Data collection

In order to obtain a comprehensive picture of changes in health conditions between pre-urban and urban populations this study includes as many osteological collections from different archaeological sites as it was possible to collect. It does not focus only on one or two characteristic sites of each period. As Griffin (Griffin, 2017) suggests, examination of large numbers of sites secures better results, as opposed to one individual site, which in the future may change its importance as a representative site of one particular period.

As the Mtskheta excavation house contained the largest part of the anthropological collection and contained materials from all three time-periods, it was the perfect place for me to start my research. Unfortunately, my field trip in 2017 to Mtskheta coincided with the relocation of the anthropological collection to the Armazi excavation house and the demolition of the original Mtskheta excavation house. All the key diaries containing the information about individuals from the anthropological collection had been packed and relocated to Armazi excavation house. Similarly, most of the anthropological materials had also been packed and were in the process of relocation. In addition, my arrival in the summer coincided with the absence of key authorised personnel on expeditions, resulting in a lack of permission for me to access many of the packed boxes with information, archaeological artefacts or anthropological specimens. Fortunately, I was allowed access to several unpacked diaries, skulls and assorted bones from the requisite periods of history. Therefore, I was able to record all the available information on arrange of early excavation skulls that were covered with shellac. Unfortunately, while these were useful for macroscopic analysis of pathological conditions, the shellac precluded using these skulls for molecular analysis of tooth calculus.

Georgian National Museum (GNM) and Laboratory of Anthropological Research (Tbilisi State University) had been established. While many of the materials at the Laboratory of Anthropological Research (TSU) had still not been unpacked, sorted or catalogued, I was able to record materials that were easily available, close to the room door. Similarly, at Georgian National Museum I could record materials from recent excavations, that had an archaeological context (as some of the materials missed the labels with the information). Despite the disruptions from the relocations of the collection, I was able to collect osteological materials from different archaeological sites and from the three historical eras.
Data was recorded on an Excel datasheet created and modified according to the “Standards for Data Collection from Human Skeletal Remains”, after (Buikstra & Ubelaker, 1994).

Due to the restricted availability of specimens, which were mostly cranial materials, it was decided to focus on porotic hyperostosis of the crania and dental pathologies of the jaw.

3.4.1 Inclusion/Exclusion criteria

Preservation of the skulls ranged from good to very poor. Poor preservation could be due to taphonomic processes, storage conditions, and damage during the archaeological excavations.

A criterion for choosing osteological materials for study was that skulls should have calvaria with at least one orbital roof intact, and that the mandible and maxilla should be present on at least on one side, with teeth in the sockets. If cranial parts that were essential to the study, such as orbits, calvaria, maxilla and mandibles with teeth were missing, those incomplete skulls were omitted from the study.

For analyse of dental pathologies, loose teeth were excluded and only teeth still in their jaw sockets were included.

Due to restricted availability of specimens, only adults and no infants, children or sub-adults were examined.

All pathologies were examined macroscopically under LED-magnifying lamps. Dental tools, gloves, aluminium foil and small plastic bags were used for collecting dental calculus (the precise method of collecting calculus will be given in chapter VI).
3.4.2 Skeletal Specimens collected

A total of 105 individual skeletal specimens from 13 osteological collections from three different time-periods that are shown in Table 1, were used for data collection and analyses. In general, each site falls into one period. The only exception was the large Samtavro cemetery, which held material from all three periods. The skeletal material from Nichbisiskhevi cemetery was mostly dated to the Late Bronze Age, except for one specimen that was dated to the Antique period. In order to provide a clearer picture of the material examined in this dissertation, I have provided below more detailed information on each of the archaeological sites, including A. the location of the site, B. the director of the excavation, C. time period represented by the site, D. number of the individuals used in this dissertation, and E. a key reference. Each site then is also indicated on the maps of the Mtskheta region (Figure 3) and of Georgia (Figure 4).
**Summary of skeletal and dental calculus samples collected for analysis**

<table>
<thead>
<tr>
<th>#</th>
<th>Skeletal collection</th>
<th>Total</th>
<th>Late Bronze 5th c. BC</th>
<th>Antique 4th - 6th cc. AD</th>
<th>Early Middle Ages 4th - 6th cc. AD</th>
<th>Dental calculus samples</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Samtavro</td>
<td>34</td>
<td>7*</td>
<td>7</td>
<td>20*</td>
<td>14</td>
</tr>
<tr>
<td>2</td>
<td>Nichbisis khevi</td>
<td>11</td>
<td>10</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Tserovani</td>
<td>12</td>
<td>12</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Natakhtari</td>
<td>16</td>
<td></td>
<td>16</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Baiatkhevi</td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Tsitsamuri III</td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Svetitskhoveli</td>
<td>2</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Bargikaria</td>
<td>3</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Kamarakhevi</td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Martazis khevi</td>
<td>15</td>
<td></td>
<td>15</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Avchaliskari</td>
<td>1</td>
<td>1*</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Tsilkani</td>
<td>6</td>
<td>6</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>Klde</td>
<td>7</td>
<td>7*</td>
<td></td>
<td></td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>110</td>
<td>29</td>
<td>39</td>
<td>42</td>
<td>20</td>
</tr>
</tbody>
</table>

*Table 1. Skeletal collection and dental calculus samples across time-periods. This table shows the total number of crania studied at each site, as well as the breakdown of the individuals by time-period. Also shown are the dental plaque samples collected from each site (*) and time-period.
Figure 3. Mtskheta region map. 1-Samtavro, 2-Nichbisis khevi, 3-Tserovani, 4-Natakhtari II, 5 Baiatkhevi, 6-Tsitsamuri III, 7-Svetitskhoveli, 8-Bargikaria, 9-Kamarakhevi, 10-Martazis Khevi, 11-Avchaliskari, 12-Tsilkani, 13-Klide

Figure 4. Map of Georgia with locations of Mtskheta region and Klide archaeological site
3.5 Archaeological Sites represented in this Study

1. Samtavro cemetery

A) Location: located in the modern town Mtskheta, on the right bank of Kura river.

B) Director of the excavation: The samples analysed in the dissertation were excavated during three archaeological campaigns: in 1958, 1959 and 1961 by the Institute of History of the Academy of Science of Georgia, directed by Simon Janashia; in 1976-1986 during the campaign of the Mtskheta Permanent Archaeological expedition directed by Andrea Apakidze; and in 2008-2010 by the joint archaeological expedition of the Georgian National Museum and the University of Melbourne, directed by Antonio Sagona.

C) Period: Most of these burials represent three periods – Late Bronze Age (The pre-urbanisation period), Antique period and the Early Middle Ages (Urbanisation period)

D) Number of individuals: In this dissertation, 110 samples were analysed from Samtavro cemetery; 29 come from the Late Bronze Age, the same amount (39) belong to the Antique period, and 42 individuals are attributed to the Early Middle Ages.

E) Reference: (Kalandadze, 1985; Sagona et al., 2010a; Sagona et al., 2010b)

2. Nichbisiskhevi cemetery

A) Location: 4.5 km west from the Samtavro, on the confluence of the Rivers Kura and Nichbura.

B) Author of the excavation: Nicbisiskhevi cemetery was excavated in 1987 and 1995 by the Mtskheta Permanent Archaeological expedition, directed by Andrea Apakidze.

C) Period: This cemetery is represented by two periods – the Late Bronze Age (116 pit burials) and the Antique period (10 pit burials).

D) Number of individuals: Among the samples analysed in the dissertation are 10 individuals from the Late Bronze Age and one from the Antique period.

E) Reference: (Rcheulishvili, 2005)
3. Tserovani II cemetery

A) Location: Located north west of Mtskheta, on the northern slope of the Skhalta ridge.

B) Author of the excavation: It was excavated in 1977-1978 by the Mtskheta Permanent Archaeological expedition, directed by Andrea Apakidze.

C) Period: At Tserovani II, 64 burials dated to the Late Bronze Age were excavated. These were mostly individual pit burials. Skeletons were placed on their right and left

D) Number of individuals: In the dissertation, Tserovani II cemetery is represented by 12 samples.

E) Reference: (Apakidze et al., 1986).

4. Natakhtari II cemetery

A) Location: located north of Mtskheta, on the right bank of the Aragvi river

B) Author of the excavation: It was excavated in 1981-1985 by the Mtskheta Permanent Archaeological expedition, directed by Andrea Apakidze.

C) Period: All burials are dated to the Antique period

D) Number of individuals: from Natakhtari II cemetery, 16 skeletons were included in the present study

E) Reference: (Apakidze & Nikolaishvili, 1987)

5. Baiatkhevi cemetery

A) Location: located north from the Samtavro cemetery, on the right bank of Baiatkhevi creek.

B) Author of the excavation: It was excavated by the Mtskheta Permanent Archaeological expedition, directed by Andrea Apakidze

C) Period: all graves are dated to the 3rd-4th centuries AD

D) Number of individuals: 1 individual is studied from this cemetery
6. Tsitsamuri III cemetery

A) Location: located east of Mtskheta on the left bank of the Aragvi river.

B) Author of the excavation: It was excavated by the Mtskheta Permanent Archaeological expedition, directed by Andrea Apakidze

C) Period: Tsitamuri III burials dating to the 1st - 3rd centuries AD

D) Number of individuals: Only one skeleton from this cemetery is examined in the dissertation

E) Reference: (Nikolaishvili, 1995)

7. Svetitskhoveli cemetery

A) Location: located in Mtskheta, in the south-eastern part of the modern town.

B) Author of the excavation: It was excavated in 1988 by the Mtskheta Permanent Archaeological expedition, directed by Andrea Apakidze.

C) Period: All burials are dated to the Antique period (Apakidze, 1989).

D) Number of individuals: In this study, two skeletons from Svetitskhoveli were examined.

E) Reference: (Apakidze et al., 1989)

8. Bargikaria cemetery

A) Location: located in the north-western part of Mtskheta, on the left bank of a small river in the area called Tsikhedids Khevi.

B) Author of the excavation: It was excavated in 1982, by the Mtskheta Permanent Archaeological expedition, directed by Andrea Apakidze

C) Period: All burials are dated to the Antique period
D) Number of individuals: In this study, three individuals were analysed from Bargikaria

E) Reference: (Apakidze et al., 1989)

10. Kamarakhevi cemetery

A) Location: located west of Mtskheta, on the right bank of Aragvi river.

B) Author of the excavation: In 1953, the Mtskheta expedition of the Institute of History of Georgia excavated directed by Shalva Amiranashvili

C) Period: All burials are dated to the Antique period

D) Number of individuals: From Kamarakhevi, one individual was analysed for the dissertation

E) Reference: (Nikolaishvili, 2005)

10. Matraziskhevi cemetery

A) Location: Located in Mtskheta, on the right bank of the Kura River.

B) Author of the excavation: In 1951, it was excavated by the Mtskheta expedition of the Institute of History of Georgia. Here were found 37 stone cist tombs. Most of these were family tombs. Skeletons were buried in the supine position.

C) Period: Based on grave goods such as glass perfume bottles, beads and bronze pins, these burials were dated to the Early Middle Ages.

D) Number of individuals: In the dissertation, 15 individuals are analysed from the Martaziskhevi burials.

E) Reference: (Ugrelidze & Amiranashvili, 1969)

11. Avchaliskari cemetery.

A) Location: Located southeast of Mtskheta, on the left bank of the Kura River.
B) Author of the excavation: It was investigated in 1983-1984 by the Mtskheta Permanent Archaeological Expedition, directed by Andrea Apakidze. At Avchaliskari cemetery, 65 pit burials, roofed with stone slabs, as well as stone-cists were uncovered. The number of individuals in each burial varied from one to six. Skeletons were buried in a supine position.

C) Period: All of these belongs to the Early Middle Ages

D) Number of individuals: In the dissertation, from Avchaliskari only one individual was analysed

E) Reference: (Apakidze & Nikolaishvili, 1987)

12. The Tsilkani tomb

A) Location: Located north of Mtskheta on the left bank of the Narekvavi river.

B) Author of the excavation: In 1979, it was excavated by the Mtskheta Permanent Archaeological expedition, directed by Andrea Apakidze

C) Period: The tomb is dated to the Early Middle Ages. It was built with well-dressed stones, measuring 3.45 x 3.25 m. Within the Tsilkani tomb eight individuals were buried in a supine position and wrapped in the cloth

D) Number of individuals: In the dissertation, 6 individuals are analysed from the Tsilkani tomb

E) Reference: (Nikolaishvili, 2005)

13. Klde cemetery

A) Location: Located to the west, about 140 km from Mtskheta, on the left bank of the Kura River

B) Author of the excavation: It was investigated in 2004-2005 by the Centre of Archaeological Studies, during the British Petroleum transregional oil pipeline salvage archaeological excavations, directed by Irine Gambashidze. At Klde there were found two forms of burial: stone-lined pit burials and jar burials. Some skeletons were buried
in the supine position, others in a flexed position. Among the artefacts found at Klde are a Roman lamp, a Parthian silver coin, ornamented glass intaglios, and terracotta figurines.

C) Period: All burials were dated to the Antique period.

D) Number of individuals: In the dissertation, 7 individuals from Klde cemetery were analysed.

E) Reference: (Gambashidze, 2006)

3.6 Sex Estimation

Adult sex determinations were conducted according to the anthropological protocols devised by the head physical anthropologist on the GAIA team, Dr. Varsha Pilbrow and were based on disciplinary standards described previously (Buikstra and Ubelaker (1994); Acsadi and Nemeski (1970); and Ubelaker (1989)). For each skull, the determination was based on an overall assessment of all sexually dimorphic structures. Incomplete skulls were scored according to all available morphological features. Assessed skulls fall into the categories given in the “Standards”: 0 = undetermined sex, 1 = female, 2 = probable female, 3 = ambiguous sex, 4 = probable male, 5 = male. Due to the small sample size, it was decided not to rationalise the samples into three categories: Probable Female was assigned to Female, Probable Male was Male, Undetermined and Ambiguous were placed in the Undetermined category.

As it is very difficult to determine age from a dry skull, without corroborating postcranial materials, and as several skulls were incomplete, I opted not to estimate age.

Table #2 shows sex distribution according to time periods. Of the 110 skulls that were studied, sex distribution in total was 37 (34%) female, 62 (56%) male, and 11 (10%) were undetermined. In the Late Bronze Age out of 29 individuals studied seven (24%) females were observed, 19 (66%) males and the sex of three (10%) individuals was undetermined. In the Antique period out of 39, 16 (41%) were females, 20 (51%) males and three (8%) undetermined. In the Early Middle Ages out of 42 studied individuals 14 (33%) were females, 23 (55%) were males and five (12%) were undetermined.
3.7 Statistical Analysis

In order to determine if there were any significant differences among the groups, statistical methods Kolmogorov-Smirnov test for normality and chi-square were conducted (p=0.05), depending on the nature of the data. For statistical analysis SPSS and GraphPad Prism software were used.

Kolmogorov-Smirnov test was conducted in order to test normal distribution of pathological changes through the time-periods. The Chi-square statistical test was performed to assess whether there were significant temporal changes in the severity and/or in the prevalence of any of pathological changes as well as differences in pathological changes between time-periods, between sexes in and within time-periods. A modification of the Chi-Square analysis (Cochran-Armitage test) was used to assess if there were significant trends in prevalence any of the pathologies across the three historical periods.

<table>
<thead>
<tr>
<th>Time-periods</th>
<th>Sex distribution across time-periods</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Female</td>
<td>Male</td>
</tr>
<tr>
<td>LBA</td>
<td>7 (24%)</td>
<td>19 (66%)</td>
</tr>
<tr>
<td>Antique</td>
<td>16 (41%)</td>
<td>20 (51%)</td>
</tr>
<tr>
<td>EMA</td>
<td>14 (33%)</td>
<td>23 (55%)</td>
</tr>
<tr>
<td>Total</td>
<td>37 (34%)</td>
<td>62 (56%)</td>
</tr>
</tbody>
</table>

Table 2. Sex distribution across time-periods
Chapter IV: Porotic hyperostosis

4.1 Introduction

Porotic hyperostosis (PH) is a pathological condition of the cranial vault bones and is typically seen on the outer table of the frontal and parietal bones, infrequently on the occipital bone and it is usually found symmetrical (Aufderheide & Rodriguez-Martin, 2006). Porotic hyperostosis on the cranial vault and the orbital roof (cribra orbitalia; CO), are the most common pathological changes detected on skeletal remains from archaeological sites. In these lesions, the diploe (spongy bone tissue) on the cranial vault is thickened and porosities appear on the outer table of the cranium and is thought to be due to marrow hypertrophy caused by over production of red blood cells (Suby, 2014), commonly in response to iron deficiency anaemia (Bothwell, 1995; Ortner, 2003; Stuart-Macadam & Kent, 1992; Walker, Bathurst, et al., 2009). According to Stuart-Macadam (1998) iron deficiency anaemia should be considered as a symptom and not as a disease, which can be caused by diverse factors, including poor diet, poor iron absorption, infections or blood loss. The lesions may vary in degree of expression. The epidemiological evidence in bio-archaeological literature suggests that porotic hyperostosis and cribra orbitalia are synonymous with iron deficiency anaemia (Rivera, 2017). Although the precise relationship between lesions of cribra orbitalia and porotic hyperostosis is not completely understood it is recognized that cribra orbitalia is an early sign of porotic hyperostosis, while porotic lesions on the cranial vault can suggest long-term anaemia (Stuart-Macadam, 1998; Stuart-Macadam, 1985; Suby, 2014; Walker, 1986). Porotic hyperostosis in older individuals may present as healed lesions, but in infants they can appear as symmetrically developed active lesions (Aufderheide & Rodriguez-Martin, 2006). The lesions on the skull were first noticed by Welcker (1988), who called the lesions Cribra Orbitalia. Hrdlicka (1914)
and Hooton (1930) connected porotic hyperostosis to different conditions but without any supporting evidence. In 1925, Cooley and Lee suggested that the lesions could be associated with anaemia (Cooley & Lee, 1925) and it has been suggested that porotic hyperostosis could be a sign of thalassemia (Angel, 1978). Stuart-Macadam and Kent (1992) collected all the evidence that existed at that time and proposed that the spread of this lesion worldwide could be connected to iron deficiency anaemia, and the lesions may be considered as adaptive responses because iron is necessary for infants and is essential for the growth of some bacteria.

After the 1950s, iron-deficiency anaemia was broadly accepted as a cause of porotic hyperostosis due to resultant marrow hypertrophy (Walker, Rhonda, et al., 2009; Walker, Bathurst, et al., 2009). This implication is based on modern clinical tests where radiographic evidence of porotic hyperostosis and haematological evidence of iron deficiency anaemia were found to coexist (Aragwal et al., 1970; Moseley, 1974; Walker, Rhonda, et al., 2009; Walker, Bathurst, et al., 2009).

Two categories of anaemia may be distinguished: genetic and acquired. Genetic anaemias such as sickle cell anaemia and thalassemia are very rare and population specific. Acquired anaemia can be caused by nutrient deficiencies and blood loss. The nutrients that are essential for red blood cell homeostasis consist mostly of essential amino acids, iron, vitamins A, B₁₂, B₆, and folic acid (Martini, 2001; Walker, Bathurst, et al., 2009). Blood loss, which is a common reason for iron deficiency anaemia, can be caused by gastrointestinal infectious and nutritional deficiencies (Walker, Bathurst, et al., 2009). Gastrointestinal infections caused by intestinal parasites such as pin worms (*Giardia lamblia* and *Enterobius vermicularis*) and giant intestinal roundworm (*Ascaris lumbricoides*) can be a reason for decreasing the level of the vitamins A and B₁₂ (Brasitus, 1983; Casterline et al., 1997; Olivares et al., 2002; Solomons, 1982; Wright et al., 1977). Another cause of anaemia can be diarrheal diseases caused by crowded and poor sanitary living conditions (Walker, Bathurst, et al., 2009). There is a link
between malnutrition and diarrheal diseases (Keusch & Farthing, 1986). Diarrheal diseases deplete vitamins C, E, B-complex, selenium and iron (Long et al., 2007).

Various studies demonstrate that porotic hyperostosis is often linked to dietary disorders, with iron deficiency anaemia being one of the main causes of this condition (Suby, 2014). Other studies show that porotic hyperostosis can be the result of iron deficiency caused by parasites or infections (Brasitus, 1983; Solomons, 1982; Walker, Rhonda, et al., 2009; Walker, Bathurst, et al., 2009; Wright et al., 1977). Infections-induced iron-deficiency might be explained by viruses consuming iron for their reproduction and by altered iron transport responses to infection Jonker and Boele van Hensbroek (2014) suggest that porotic hyperostosis is the result of diseases related to diet, hygiene, parasites, and infections.

Here we should make a special note of the osteological paradox. At the end of 20th century, the osteological paradox was proposed by Wood et al. (1992), who suggested that individuals with pathological changes in their skeletons could be considered survivors rather than those that died of the disease before any bone pathology appeared (Siek et al., 2013; Wood et al., 1992). For skeletal lesions to occur, an individual must live with a disease for a long time.

Skeletal pathological responses are slow, and it can take from one year to a decade for the marks of disease to become noticeable on bones (Roberts, 2007). The osteological paradox focuses mainly on two points in time: the time of reduction in the disease and the time of death. An individual with a diseased skeleton should not be considered unhealthy, as it is plausible that they resisted the illness and lived with it chronically for many years rather than dying from a more serious and acute form. Consequently, an absence of pathological changes on the bones does not necessarily indicate the nonexistence of disease, while the presence of lesions could be a sign of more robust health (Wood et al., 1992).
To illustrate this osteological paradox, Wood et al. (1992) give an example of a living population consisting of three subpopulations. Members of all three groups could potentially show an acquired disorder resulting from some form of stress. Members of the first subpopulation never experience the stress and none of them have pathological changes on their bones. The second subgroup is exposed to moderate stress, the sickness spreads widely and lasts long enough to cause skeleton lesions but results in few deaths. The third subgroup experiences heavy stress and its members die soon afterwards, before any bony lesions appear. As a result the first and the third groups are considered as a healthy subgroups, while the second subgroup may be determined as unhealthy by bioarchaeologists (Wood et al., 1992).

Many scholars have criticised the osteological paradox proposed by Wood et al. (1992). Goodman (1993) suggested that it was focused on only a single marker of health rather than various markers, and that Wood et al. (1992) misinterpreted the goals of paleoepidemiology by constructing models that did not reflect biological realities or convincing cultural contexts. Cohen is among other scholars who did not agree with Wood et al. (1992), pointing out that “each pathology is telling us something of its own character and the lifestyle of its victims by its pattern in the skeletons” (Cohen et al., 1994).

Bio-archaeology can be considered an equal partnership between osteology and archaeology, designed to result in more accurate data for reconstructing the lives of past populations than either discipline can achieve alone (Buikstra, 1991, 2006). According to Larsen and Walker (2010) research in bio-archaeology is most successful if it incorporates methods and insights from other disciplines with similar interests.
4.2 Methods

In this study, I examined the macroscopic presence and extent of porotic hyperostosis on 105 dry crania with at least one orbital roof and preserved calvaria. The degree, location and activity of porotic lesions on the crania were documented following the “Standards” of Buikstra and Ubelaker (1994), modified from Stuart-Macadam (1985) (Table 3). Examples of the types of hyperostosis encountered in the specimens in this study are shown in Figure 5.

<table>
<thead>
<tr>
<th>#</th>
<th>Degree</th>
<th>Anatomical Location</th>
<th>Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Not observable</td>
<td>Not observable</td>
<td>Not observable</td>
</tr>
<tr>
<td>1</td>
<td>Barely discernible</td>
<td>Orbits</td>
<td>Active</td>
</tr>
<tr>
<td>2</td>
<td>Porosity only</td>
<td>Adjacent to sutures</td>
<td>Healed</td>
</tr>
<tr>
<td>3</td>
<td>Porosity with coalescence</td>
<td>Near bosses or within squamous portion of occipital</td>
<td>Mixed reaction: evidence of healing+active</td>
</tr>
<tr>
<td></td>
<td>of foramina, no thickening</td>
<td></td>
<td>lesions</td>
</tr>
<tr>
<td>4</td>
<td>Coalescing foramina with</td>
<td>Both adjacent to suture and within orbits</td>
<td></td>
</tr>
<tr>
<td></td>
<td>increased thickness</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
<td>Both adjacent to suture and near bosses/in squamous</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>portion of occipital</td>
<td></td>
</tr>
</tbody>
</table>

Table 3. Porotic lesions according degree of severity, location and activity
Figure 5. Examples of porotic lesions according degree of severity, location and activity using the standards of Buikstra an Ubelaker (1994), modified from Stuart-Macadam (1985). A. Degree-1, Location-1, Activity-0 (Samtavro cemetery). B. Degree-2, Location-1, Activity-3(Tsikhedidids khevi). C. Degree – 3, Location – 1, Activity – 3 (Natakhtari). D. Degree – 3, Location – 1, Activity – 1 (Natakhtari). E. Degree – 1, Location – 4, Activity – 0 (Nichbis khevi). F. Degree – 2, Location – 4, Activity – 3 (Natakhtari). G. Degree – 2, Location – 5, Activity – 2 (Martazis khevi). H. Degree – 2, Location – 1, Activity – 2 (Samtavro cemetery)
4.3 Statistical Analyses

For the statistical analysis, three lesion categories were compared among time periods and between sexes and between sex across time-periods (presence/absence of lesions, degrees of severity, and three degrees of activity were included: active, healed and mixed reaction). However, analyses comparing different anatomical location of the pathologies were not conducted. For each condition, the data were subjected to Chi-square tests for univariate nominal data using SPSS and GraphPad Prism to test for significant differences and for trends among the data. The Kolmogorov-Smirnov test was initially conducted to test for normality and to determine if data is parametric or non-parametric and then to choose appropriate statistical method that would be useful for analysing this data.

4.3 Results - Porotic lesions, degree of severity and activity

4.3.1 Porotic hyperostosis

Temporal comparison of prevalence of porotic lesions, degree of severity and degree of activity among the three time-periods reveal a few significant trends. However, before the results can be discussed it is important to examine distribution of lesions across time periods, and in sex across time-periods. Table 4 shows prevalence of porotic lesions across time-periods and between sex across time-periods. Of the 105 individual specimens examined, 63 (60%), exhibited cranial hyperostosis. For each of the different historical periods, 45% (13/29) of the Late Bronze Age, 62% (24/39) of the Antique period and 70% (26/37) Early Middle Ages specimens exhibited the lesions. Analysis of the presence of lesions according to gender revealed that 70% (26/37) of female, 53% (32/60) of male, and 62% (5/8) of the undetermined sex groups had porotic lesions. Kolmogorov – Smirnov test of the distribution of the lesions among the three time-period samples and lesions between sexes, indicate that they are
significantly different (p<0.05) and thus not normally distributed. No statistical differences of the lesions among the time-periods were detected (chi-square, p=0.108). Likewise, no significant difference of the lesions was observed between sexes (chi-square, p=0.252). In the Late Bronze Age, there was a greater prevalence of porotic lesions among males (9/13 individuals with lesions in this period were males). Even proportional to the sample sizes of males and females, the frequency of lesions was higher in males 47% (9/19) than in females 43% (3/7). Only one (33%) of undetermined sex exhibited the lesion out of three. The number of porotic lesions in the Antique period was equally distributed among males and females – 11 in each category, although the frequency of females with lesions is higher 69% (11/16) than males with lesions 55% (11/20). Similarly, in the Early Middle Ages porotic lesions were detected in equal numbers of males and females – 12 in each category, but once again there were proportionally more females with lesions 86% (12/14) than males with lesions 57% (12/21). This suggests that over time, porotic lesions are more frequently encountered in females than males. However, there was a significant trend in prevalence of the lesions across time periods (chi-square, p=0.0385) and between sex (chi-square, p=0.0267) (Figures 6, 7, 8).
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*Table 4. Distribution of porotic lesions among time-periods, between sex and between sex across time-periods*
Figure 6. Percentage of prevalence of porotic lesions across time-periods. There appeared to be a significant trend for increased prevalence of porotic lesions from Late Bronze Age to Antique period and Early Middle Ages.

Figure 7. Presence/absence of porotic hyperostosis between sex.
4.3.2. Degree of severity

In addition to investigating the prevalence of pathological changes, it is important to take severity of lesions into consideration, as it could be an indicator of effects in a population over time. For instance, severity over time may change even if the prevalence stays the same. Comparison of each pathological change between sexes and within time-periods is also an important indicator of social change as it may reflect how males and females experience different level of stress including diet change.

Out of 105 individuals 41 (39%) were observed with only porosity (degree 2), 21 (20%) were with porosity with coalescence of foramina, no thickening (degree 3) and in only one (1%) individual was detected coalescing foramina with increased thickness (degree 4). Degree 1 is not considered as a pathological change.

In Late Bronze Age, degree 2 was observed on 28% (8/29) of individuals, degree 3 on 17% (5/29) of individuals and degree 4 was not observed in that time-period. In Antique period
degree 2 was observed on 33% (13/39) of individuals, degree 3 was observed on 26% (10/39) individuals and on 3% (1/39) of individual was observed with the degree 4. In Early Middle Ages degree 2 was detected on 54% (20/37) individuals, degree 3 was observed on 16% (6/37) of individuals and no individuals were observed with the degree 4 (Fig. 9). Statistical analysis of severity of the lesions in the three periods did not reveal any significant differences or trend (chi-square, p=0.186).

Total in females, degree 2 was detected on 43% (16/37) of individuals, degree 3 was observed on 24% (9/37) of individuals and only 3% (1/37) of individual had a degree 4 lesion. Total in males 35% (21/60) of individuals were observed with the degree 2, on 18% (11/60) of individuals were detected degree 3 and degree 4 was not detected on any individual. In undetermined sex group, degree 2 was observed on 40% (4/8) individuals, degree 3 was detected on 12% (1/8) individual and degree 4 was not detected on any individual (Fig. 10). No statistical differences of the degree of severity was detected between sexes (chi-square, p=0.568).
In Late Bronze Age 43% (3/7) of females were detected with degree 2, degrees 3 and degree 4 were not observed in this group. In males in this period 26% (5/19) of individuals were observed with degree 2, degree 3 was detected on 21% (4/19) of individuals, and degree 4 was not observed in that time-period and group. In undetermined sex group individuals, degree 2 and degree 4 were not observed on any individuals and degree 3 was detected on 33% (1/3) of individual. In Antique period in females degree 2 was observed on 19% (3/16) of individuals, degree 3 was seen 44% (7/16) of individuals, and degree 4 was detected on 6% (1/16) of individual. In males in this time-period, degree 2 was observed on 40% (8/20) of individuals, degree 3 was detected on 15% (3/20) of individuals and degree 4 was not observed in this group. Only degree 2 was observed on 67% (2/3) of individuals in undetermined sex group in Antique period. In Early Middle Ages in females degree 2 was observed on 71% (10/14) of individuals, degree 3 was seen on 14% (2/14) and degree 4 was not detected on any females in this time-period. In males in this period degree 2 was observed on 38% (8/21) on individuals, degree 3 was detected on 19% (4/21) of individuals and degree 4 was not seen in
this group. In undetermined sex group only degree 2 was observed on 100% (2/2) of individuals (Fig.11). Statistical comparison of degree of severity did not show significant difference between sex across time-periods (chi-square, p=0.568)

![Figure 11.Percentage of the degree of severity between sexes across time-periods](image)

### 4.3.3 Degree of Activity

Statistically was compared degrees of activity between time-periods, between sex and between sex across time-periods. The statistical test was performed between the individuals that had lesions (63 individuals), those without any pathological changes were excluded from the test. In total active degree of porotic lesions was observed on 54% (34/63) of individuals, 16% (10/63) of individuals had healed lesions, and 30% (19/63) had mixed (active and healed) lesions.

A number of individuals with the degrees of activity were detected in each time-period. Given the smaller sample size for the Late Bronze Age, the percentage of individuals is higher. In the Late Bronze Age most individuals with lesions had active lesions - 69% (9/13); there was a smaller proportion of individuals with, mixed degree of activity - 31% (4/13). There were no healed lesions observed in this time-period. In Antique period 54% (13/24) of individuals were detected with the active degree, 12% (3/24) of individuals had healed degree
of activity and 33 % (8/33) of individuals exhibited mixed degree of activity. In the Early Middle Ages 46% (12/26) had active degree, and a similar percentage and number—27% (7/26) of individuals each were present with healed and mixed degrees of activity of lesions (Fig. 12). Thus, the frequency of individuals with active lesions decreased over the time and healed lesions increased between the pre-urbanised time of the Bronze Age and the urbanised period of the Antique and Early Middle Ages. Statistical analysis in the level of degree of activity across time-periods reveal significant differences (chi-square, p=0.0001).

Figure #12. Percentage of degree of activity across time-periods

Figure #13 shows the break-down of the degree of activity of lesions among the sexes. Active degree of porotic lesions in females were observed on 54% (14/26) of individuals, healed degree on 15% (4/26) of individuals and mixed degree on 31% (8/26) of individuals. In males, active degree was detected on 47% (15/32) of individuals, healed degree was seen on 19% (6/32) of individuals and mixed degree was observed on 34% (11/32) of individuals. Only active degree was detected on 100% (5/5) of individuals in undetermined sex group. Statistical analysis of comparison of degrees of activity between sex did not reveal any significant difference (chi-square, p=0.295).
In the Late Bronze Age healed degree of activity was not observed at all. In females in this period active degree of porotic lesions was detected on 67% (2/3) of individuals and mixed degree on 33% (1/3) of individuals. In males, active degree was observed on 67% (6/9) of individuals and mixed degree on 33% (3/9) of individuals. Only active degree was seen on 100% (1/1) of individual in undetermined sex group. In Antique period active degree of the lesions were detected on 55% (6/11) of females, healed degree was observed on 9% (1/11) and mixed degree was seen on 36% (4/11) of females. In males in this time-period active degree was observed on 46% (5/11) of individuals, healed degree on 18% (2/11) and mixed degree of porotic lesions was detected on 36% (4/11) of individuals. Only active degree was observed on 100% (2/2) of individuals in undetermined sex group. In Early Middle Ages in females active degree was examined on 50% (6/12) of individuals, similar number of individuals -25% (3/12) were detected with healed and mixed degrees. Similar number of males 33% (4/12) in this period exhibited active, healed and mixed degrees of activity. Similar to other periods in this period only active degree of the lesions were detected on 100% (5/5) of individuals in undetermined sex group. Figure 14 is a stacked histogram showing the percentage of cases by sex of the three degrees of activity of lesions over the three time periods. It shows that there is
no evidence of healed lesions in the Late Bronze Age, but such lesions increase in frequency over subsequent periods. Statistical analysis did not reveal any significant difference between sex across time-periods (chi-square, p=0.7831)

![Figure 14. Degree of activity between sexes across time-periods](image)

To summarize the results so far, we see: (1) an increased trend in the prevalence of porotic lesions over time; (2) a greater number of females with porotic lesions over time; (3) a mild increased prevalence of moderately severe lesions (grade 2) but a moderate decline in more severe lesions (grade 3), and (4) a greater frequency of healed lesions over time.

4.4 Discussion

Before discussing the results an important caveat to bear in mind is that the limited sample numbers presented here may not be entirely representative of the populations in Mtskheta during three time periods. However, the analysis of over 100 samples does provide some insights into the health status of the people in the region in each time period and is the first attempt at a systematic examination of porotic hyperostosis in skeletal materials excavated on the territory of Georgia. While there were no significant differences in prevalence or in severity of porotic hyperostosis among the three periods, there were significant trends showing
an increased prevalence of porotic hyperostosis from the pre-urbanisation Late Bronze Age to the urbanised Antique and Early Middle Ages periods.

There were three major trends indicating stress among the three temporal times: 1) there was a great prevalence of the lesions over the time \( (p=0.0385) \), 2) there was an increase of the lesions in females across time periods than in males \( (p=0.0267) \), 3) increase of healed lesions over the time \( (p=0.0001) \). From these data, I propose that the increase in porotic lesions in Mtskheta over the time is related to two elements: infection and diet. The first one, infection, is likely to be directly connected to the emergence of urbanisation, characterized by dense population and poor sanitation, which creates the perfect environment for the spread of infections among the population. The second might be linked to the social hierarchization and political instability that characterized the end of the Iberian kingdom. Under these circumstances, certain categories of population may have had limited access to the food and suffered from malnutrition. Both mechanisms could lead to anaemia, which has been demonstrated to be causal for porotic lesions.

While the above mechanisms seem the most plausible, other stress markers such as hereditary haemolytic anaemia (sickle cell anaemia), thalassemia and zoonotic diseases that cause blood loss (Vercellotti, 2010), should also be considered. Various radiographic and anatomical studies have shown that severe forms of hereditary haemolytic anaemia such as sickleemia and thalassemia result in porotic lesions (Hershkovitz, 1997; Sebes & Diggs, 1979; Walker, Bathurst, et al., 2009). However, these conditions are rare, population specific or often related to endemic malaria (Sullivan, 2010; Walker, Rhonda, et al., 2009). Although Mtskheta is located on the confluences of rives, evidence for endemic malaria has never been described for this area. For this reason, it is difficult to attribute the presence of porotic lesions to these two forms of hereditary hemolitic anaemia in this area over the time. Zoonotic anaemia, caused by parasitic vectors such as intestinal worms, hookworms, *Ascaris* and *Trichuris*; (Bechir, 2014) may be a possible contributor as these parasitic worms are transmitted from cattle to humans and can cause intestinal blood loss that often results in anaemia (Stoltzfus et al., 1997). Whether the increased reliance on domesticated animals for food has contributed to the increased prevalence of porotic hyperostosis remains to be studied.

The slightly greater prevalence of the lesions in females over time suggests that the women may have faced greater stresses than men. This may plausibly be connected to the custom of prolonged breastfeeding, which can be a risk for vitamin B12 deficiency and a cause of anaemia (Walker, Bathurst, et al., 2009; Weiss, 2004).
Increased frequencies of healed degrees of porotic lesions may potentially be linked to the advance of lifestyle and development of medicine. The occurrence of glass bottles in Antique and Early Middle Ages graves (Apakidze et al., 1981) supports the notion that there was an increased awareness and development of medical and herbal treatments as palynological examination of the contents of these artefacts is consistent with their use for various medical purposes (Kvavadze, 2018).

The only other research comparable to this study has been done on skeletal material from Doglaura cemetery (Georgia), dated to the Late Bronze Age. This cemetery is located in Shida kartli region, east of Mtskheta, near the Kura River and, like all Late Bronze Age archaeological sites in the territory of the Greater Mtskheta, it is also part of Samtavro archaeological culture. Examination of the skeletal material from this site revealed a high frequency of cribra orbitalia (Bertoldi, 2016), which to a certain extent supports my data in the increased prevalence of porotic hyperostosis from the Late Bronze Age onwards.
Chapter V: Dental Diseases – Caries, Periapical lesions, Antemortem Tooth Loss and Calculus

5.1 Oral health

The Neolithic Revolution was a wide-scale shift from hunter-gatherer to an agricultural settlement lifestyle, particularly in the fertile valleys of the current Middle East and spread to the Caucuses in the Late Bronze Age (15th – 6th centuries BC). The change in diet and more sedentary settlement lifestyle has been hypothesised to have affected negatively the health of the population. The subsequent emergence of state society and increased urbanisation and social hierarchization during the Antique and Early Middle Ages periods may have exacerbated such effects on population health. As teeth are good source of information about lifestyle and are affected directly by diet (Latham, 2013). I investigated the skeletal remains and dental materials from Mtskheta for dental caries, periapical lesions, antemortem tooth loss and dental plaque-calculus. In this chapter I have provided a brief summary about each of these pathological conditions, the methods and materials used, before summarising and discussing the results.

5.2 Caries

Generally, in the archaeological context teeth survive well and provide important information about dental diseases, social habits, and dental wear (Waldron, 2009). As described in sections 1.5 to 1.6, caries is the most prevalent among dental diseases. While the
development of caries is multifactorial and can involve various bacteria (Aufderheide & Rodriguez-Martin, 2006), there appear to be three main factors involved in the development of caries: dental plaque with bacterial biofilm, the presence of fermentable carbohydrates and the production of acid (Waldron, 2009). The bacteria (e.g. *Streptococci mutans* and *Lactobacilli*) that accumulate in the organic matrix of the biofilm metabolise fermentable carbohydrates and produce acid that eventually leads to demineralisation of the tooth (Kutsch, 2014). Hillson (1996) suggests that caries appears in two main forms: as opaque spots and large sized cavities. It is the balance between remineralisation and demineralisation that defines the development of caries. Remineralisation occurs when saliva restores necessary levels of pH, but demineralisation occurs when bacterial biofilm persists (Waldron, 2009). Archaeological evidence shows that there is significant difference in the frequency of caries between the populations with mobile lifestyle and sedentary populations following agricultural activities (Hillson, 2001). The introduction of agriculture in ancient populations is associated with changes in dietary habits, particularly with consumption of grains containing fermentable carbohydrates, which are converted to sugars and contribute to the biofilm (Touger-Decker, 2003). Carbohydrates are believed to play a strong role in the incidence of caries, with the frequency of carbohydrate consumption being directly correlated with the occurrence of caries (Houte, 1994; Larsen, 2006). Thus, studying the prevalence of caries may be one way to reconstruct the health and lifestyle of a past population.
5.3 Periapical Lesions

Another common tooth pathology that is associated with various dental diseases including caries and periodontal disease are periapical cavities, also known as abscesses. (Waldron, 2009). The term “abscess” is used to describe an accumulation of micro-organisms in the pulp cavity that causes inflammation (Roberts & Manchester, 2010). The abscess can be recognised by the way in which it destroys the anterior alveolar wall that leaves the pulp cavity exposed. While these cavities are often described as abscess cavities, in fact there are three types of periapical lesions: 1. Cysts, 2. Granulomas, 3 Abscesses (Waldron, 2009). All these lesions can appear from infection, but the outcome depends on the host’s immune response and the virulence of the infection (Waldron, 2009). There are several causes of periapical lesions. One is bacteria spreading from a carious cavity, another is trauma and attrition leading to a cavity a cavity (Roberts & Manchester, 2010). Finally, the dental pulp can be infected by aerobic and anaerobic micro-organisms migrating along the root canal through the apical foramen and the subsequent inflammation appearing in the periapical tissues. The initial response to the infection is formation of a granuloma which leads to the development of a cyst. The formation of an acute abscess starts with the accumulation of pus in the cavity of the granuloma (Waldron, 2009). Abscesses also can develop if a person has periodontal disease and a periodontal pocket; periodontal disease can be initiated by an accumulation of plaque between the tooth and soft tissues of the gums (Hillson, 1996). The aetiology of acute dental abscess as has already been mentioned is polymicrobial– facultative anaerobes such as the viridans group streptococci and Streptococcus anginosus with anaerobic cocci, Prevotella and Fusobacterium species, Treponema species, Gram-positive anaerobic-Bulleidia extracta, Cryptobacterium curtum and Mogibacterium timidum can cause the inflammation (Robertson & Smith, 2009).
5.4 Antemortem Tooth Loss

Dental caries and periodontal disease can also be a cause of antemortem tooth loss (AMTL) (Larsen, 1997). Due to periodontal disease there is a loss of alveolar bone. Substantial horizontal bone loss leads to teeth loss, because of the loss of ability to keep teeth in their sockets (Hillson, 1996). Healed soft tissues over the tooth remodels the tooth socket without any trace of the former foramen in the alveolar bone (Larsen, 1997). Even though aetiologies of antemortem teeth loss are problematic, because evidence can be lost (in case of carious teeth), it is closely associated with dental caries and periodontal disease (Larsen, 1997). The prevalence of antemortem tooth loss can be used as an indicator of a population’s oral health. However, sometimes loss of teeth may not represent oral pathologies but may be due to aging (Hillson, 1996; Larsen, 1997).

5.5 Calculus

Calculus arises due to mineralisation of the bacterial biofilm on the tooth surface. Accumulation of dental calculus, also known as plaque, can lead to dental caries (Hillson, 1996). Calculus can contain numerous microorganisms that are found throughout the mouth, on the tongue, gums, lips and cheeks. While in this chapter I investigate the prevalence of calculus in teeth specimens from Mtskheta, the next chapter will investigate in greater detail the microorganisms that can be detected by DNA analysis of calculus samples obtained from these skeletal remains.
5.2 Methods and Materials

The prevalence and extent of dental pathologies (caries, periapical lesions, antemortem tooth loss, calculus) were documented from skeletal materials obtained for 102 individuals with preserved jaw and teeth. An inclusion criterion for the study of dental pathologies was that individuals possessed at least one side jaw with teeth. Loose teeth without maxilla or mandible were excluded from the analysis. The details of the samples analysed, their origin site and the period to which they were dated are shown in Table 5. This included a total of 25 individuals from the Late Bronze Age, 33 individuals from the Antique period and 42 from the Early Middle Ages. Chi-square analyses (including trend analysis) were used to compare dental pathologies and its severity between sex, among time-periods and between the sexes across time-periods.

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5.2.1 Caries

As for the analyses of the Porotic hyperostosis, I followed the “Standards” of Buikstra and Ubelaker (1994) to classify and document the dental pathologies. In addition, the location of caries was recorded by the method modified from (Moore & Corbett, 1971) where the pathology is evaluated by the location:

0. No lesion present.
1. Occlusal Surface: all grooves, pits, casps, dentin exposures, and the buccal and lingual grooves of the molars
2. Interproximal Surface: includes the mesial and distal cervical regions
3. Smooth Surface: buccal (labial) and lingual surfaces other than grooves
4. Cervical Caries: originates at any cemento-enamel junction (CEJ), except the interproximal regions
5. Root Caries: below the CEJ
6. Large Caries: cavities that have destroyed so much of the tooth that they cannot be assigned a surface of origin
7. Noncarious Pulp Exposure

All data was based on macroscopic observations of caries on all available permanent teeth.
5.2.2 Periapical Lesions

Similar to documentation of caries and porotic hyperostosis, periapical lesions or abscesses were documented by macroscopic observations of all permanent teeth. The lesions can often be identified by the presence of a drainage channel that goes to the apex of the tooth root through the alveolar bone (Figure 15). Periapical lesions were recorded by presence and location, where “1” indicates buccal or labial alveolar channel and “2” – lingual perforation.

Figure 15. Abscess of right mandibular P1 showing a lingual drainage channel (red arrow) from the root apex through the alveolar bone

5.2.3 Antemortem Tooth Loss

Antemortem tooth loss was examined by recording the total number of permanent teeth lost per jawbone that was involved in the study.
Statistical analysis

To facilitate sufficient power for the statistical analysis, two sub-categories were analysed for each dental pathology, as follows:

1. Absent/present,
2. Number of lesions per individual – severity of dental conditions.

The conditions were analysed between time-periods, between sex and between sex across time-periods. Like porotic lesions, for statistical analysis of dental pathologies Kolmogorov-Smirnov normal distribution test and Chi-square test were used. SPSS, GraphPad PRISM and Excel were used to perform the tests and to create graphs.

5.5. Results

5.5.1 Caries

Temporal comparison of prevalence of carious lesions and severities among the three time-periods reveal no significant differences or significant trends. However, before the results can be discussed it is important to examine distribution of the lesions across time periods, and in sex across time-periods. Table # 6 shows the distribution of carious lesions among the periods, between sex and between sex across time-periods. Of the 102 specimens examined 19% (19/102) had caries in at least one tooth, suggesting a relatively low prevalence of caries overall. When separated according to the historical periods, 28% (7/25) of Late Bronze Age, 17% (6/35) of Antique and 14% (6/42) of Early Middle Ages individuals had at least one caries lesion. Gender based analyses of the frequency of caries revealed that 21% (7/33) of females
had caries, 15% (9/60) were males with the condition and 33% (3/9) were from undetermined sex group that had a caries. The results of the statistical analysis did not reveal any significant differences. Chi-square analyses showed no significant differences of carious lesions among the time-periods (p=0.364). The prevalence of carious lesions appeared to decrease from LBA to EMA (Fig. 16), however this was not significant. Likewise, gender based statistical analysis did not reveal any significant difference (Chi-square, p=0.398). Taken in an account the proportion of males and females, the results show that lesions were more prevalent in females than in males. (Fig.17 ).

<table>
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</tr>
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<td>82.9%</td>
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Figure 16. Prevalence of caries across time-periods. The data suggest there is a decreasing trend across the periods; however, this was not significant (p=0.364)

<table>
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<th>Count</th>
<th>%</th>
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<td>60</td>
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<td>9.8%</td>
<td>83</td>
<td>19</td>
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Table 6. Distribution of carious lesions across time-periods and in sex across time-periods
The male and female specimens were further segregated according to time-periods (Fig. 18). Of the 25 Late Bronze Age specimens, 29% (2/7) of female, 23% (4/17) of male LBA individuals and a single undetermined gender individual (100%) had caries. Of the 35 Antique period specimens, 17% (2/12) of female, 15% (3/20) of male and 33% (1/3) of undetermined gender individuals had caries. In the 42 Early Middle Age specimens, 21% (3/14) of female, 9% (2/23) male and 20% (1/5) of undetermined gender individuals had caries lesions. No statistical difference was revealed in prevalence of caries lesions between the sexes across the three time-periods (chi-square, p=0.377).
To investigate if there were differences in the level of dental health, I quantified the number of caries per individual specimen. No statistical difference was revealed of carious lesions per individual between time-periods (chi-square, $p=0.554$), between sex (chi-square, $p=0.499$) and between sex across time-periods (chi-square, $p=0.431$). Out of total 102 individuals 14% (14/102) had carious lesions only on one tooth, 4% (4/102) had on two teeth and only 1% (1/102) individual was observed with carious lesions on three teeth. In Late Bronze Age 24% (6/25) of individuals had caries on one tooth and only 4% (1/25) individual had caries on two teeth. In Antique period 11% (4/35) with the carious lesions, had caries on one tooth, and equal number one 3% (1/35) had caries on two and three teeth. In Early Middle Ages 9% (4/42) of individuals with the caries, had the lesion on one tooth and 5% (2/42) of individuals had caries on two teeth (Fig. 19.).
To determine if there were any differences between males and females, I analysed the number of caries per individual according to gender. There was no statistical difference (chi-square, $p=0.499$). Of the 33 females 18% (6/33) had caries on one tooth and 3% (1/33) individual had lesions on two teeth. Out of 60 males, caries on one tooth was observed in 8% (5/60) individuals, on two teeth in 5% (3/60) individuals and only 2% (1/60) individual had caries on three teeth. Out of nine undetermined individuals 33% (3/9) individuals were observed with the lesions on one tooth (Fig. 20).
I also examined if there were any differential effects on male or female dental health across the three periods. There was not significant difference in number of carious lesions per individual between sex across time-periods (chi-square, p=0.436). In Late Bronze Age, 29% (2/7) of females had caries lesions on one tooth. In males the lesions on one tooth was observed on 18% (3/17) of individuals and only 6% (1/17) of individual had the condition on two teeth. In undetermined sex group caries was detected only on one tooth on 100% (1/1) of individual. In Antique period 17% (2/12) of females were observed with the lesion on one tooth. In males 5% (1/20) of individuals were observed with lesions on one, two or three teeth. In undetermined gender group 33% (1/3) of individual had a lesion on one tooth. In Early Middle Ages 14% (2/14) females had caries on one tooth and 7% (1/14) had the lesion on two teeth. There was equal number of males 4% (1/23), with the caries that had the lesions on one and two teeth. In undetermined sex group only 20% (1/5) of individuals had caries on one tooth (Fig. 21).

*Figure 20. Percentage of carious lesions per individual between sex*
5.5.2 Periapical lesions

The results of statistical analysis did not reveal any significant difference or trend of periapical lesions among three time periods (chi-square, p=0.8754) or between sex (chi-square, p=0.9268) or between sex across time-periods (p=0.960). Quantification of periapical lesions showed that overall, only 22% (23/102) individuals had an abscess. In the Late Bronze Age, 24% (6/25) of individuals had the lesions. In the Antique period 23% (8/35) of individuals were observed with the condition and in the Early Middle Ages 21% (9/24) had periapical lesions (Fig. 22.)
Quantification of periapical lesions according to gender showed that 24% (8/33) of females, 22% (13/60) of males and 22% (2/9) of undetermined gender individuals were affected (Fig. 23).
In Late Bronze Age, 14% (1/7) of females, 29% (5/17) of males and none of the undetermined gender individuals were detected with periapical lesions. In Antique period, 25% (3/12) of females, 20% (4/20) of males and 33% (1/3) of undetermined individuals exhibited the condition. In Early Middle Ages, similar number 29% (4/14) of females and males 17% (4/23) were observed with it, only 20% (1/5) undetermined individual had the lesions (Fig. 24).

![Figure 24. Percentage of periapical lesions between sex across time-periods](image)

The results of statistical analysis of periapical lesions per individual – cases, did not reveal any significant differences among three time-period samples (chi-square, p=0.969) or between sex (chi-square, p=0.960) or between sex across time-periods (chi-square, p=0.627). Total one case of periapical lesions was detected on 14% (14/102) of individuals, 4% (4/102) had two cases of abscesses, similar number (one (1%)) had three, four and five cases of abscesses. In Late Bronze Age 12% (3/25) had one case of abscesses and only 4 % (1/25) individual had 2 cases of abscesses. In Antique period 14% (5/35) had one case of the lesions and 9% (3/35) two cases of the condition. In Early Middle Ages 14% (6/42) of individuals had...
one case of periapical lesions and similar number 2% (1/42) had three, four and five cases of the condition (Fig. 25)

![Bar chart showing percentage of cases of periapical lesions among three time-periods](image)

*Figure 25. Percentage of cases of periapical lesions among three time-periods*

Out of total 33 females - 12% (4/33) had one case of abscesses, 6% (2/33) had two cases of abscesses and only 3% (1/33) had four cases of abscesses. Out of 60 males - 13% (8/60) of individuals were observed with one case of abscesses, 3% (2/60) had two cases of abscesses, 2% (1/60) had three cases of abscesses and only 2% (1/60) had 5 cases of abscesses. Out of nine undetermined individuals only 22% (2/9) of individuals had one case of abscesses (Fig. 26).
In Late Bronze Age no females out of seven and no undetermined individuals out of one were observed with the periapical lesions, 18% (3/17) males were observed with the one case of the lesions and 6% (1/17) males with two cases. In Antique period 8 % (1/12) had one case of periapical lesions and 17% (2/12) had two cases of the lesions. In males 15 (3/20) were observed with one case of periapical lesions and 5% (1/20) with two cases of the lesions. No undetermined individuals out of three were observed with the abscesses. In Early Middle Ages 21% (3/14) were detected with one case of the condition and 7% (1/14) - with four cases of abscesses. In males 9% (2/23) were detected with one case of periapical lesions and similar number – one (4%) individuals were observed with three and five cases (Fig. 27)
5.5.3 Antemortem Tooth Loss

The results of statistical analysis did not reveal any significant differences among the three time-period sample (chi-square, p = 0.126). In total antemortem tooth loss was observed on 36% (37/102) individuals. In Late Bronze Age 36% (9/25) of individuals had the condition. In Antique period 49% (17/35) of individuals were detected with antemortem tooth loss. In Early Middle Ages 26% (11/42) of individuals had the condition (Fig. 28).
Antemortem tooth loss (AMTL) was compared between sexes and between sexes across time periods. As the results showed males (43% (26/60)) exhibited the condition more than females (18% (6/33)) and 56% (5/9) of individuals from undetermined sex group had the condition. Statistical analysis between sex revealed a significant difference (chi-square, p=0.025) (Fig. 29). Statistically there was not significant difference the comparison of the condition between sex across time-periods. In Late Bronze Age 29% (2/7) of females were observed with antemortem tooth loss. In males 41% (7/17) had the condition and no individual were observed with the lesion in undetermined sex group. In Antique period 33% (4/12) of females were observed with the condition, 55% (11/20) of males had the lesions and 67% (2/3) of individuals from undetermined sex group were observed with antemortem tooth loss. In Early Middle Ages no females out of 14 were observed with the condition, 35% (8/23) of males had the condition and in undetermined sex group 60% (3/5) of individuals were detected with the lesions (Fig. 30).
Comparison of the severity of antemortem teeth loss were conducted according to number of teeth lost. Statistically there was not significant difference of the severity of the condition between time-periods (chi-square, p=.304) between sex (chi-square, p=.647) and between sex across time-periods (chi-square, p=.647). Out of 102 individuals, 15% (15/102) had lost one tooth antemortem, 3% (3/102) had lost two teeth, similar number 5% (5/102) have
lost three, four and five teeth, similar number 1% (1/102) have lost six, eight, and 11 teeth, 2% (2/102) individuals had lost nine teeth. In Late Bronze Age 16% (4/25) had lost one tooth, 4% (1/25) had lost two teeth, no individuals were recorded with three, four and 11 teeth lost. Similar number 4% (1/25) individuals had lost five, six, eight and nine teeth. In Antique period 17% (6/35) had one tooth lost, 6% (2/35) individuals had lost two teeth, similar number 9% (3/35) had lost three and five teeth, similar number 3% (1/35) individuals were observed with four, nine and 11 teeth antemortem tooth lost. In Early Middle Ages 12% (5/42) had lost one tooth, 5% (2/42) had lost three teeth, 10% (4/42) had lost four teeth and 2% (1/42) had lost five teeth (Fig. 31).

![Figure 31. Percentage of the severity of AMTL across time-periods](image)

In total from females 9% (3/33) had lost one tooth, similar number of individuals 3% (1/33) had lost three and five teeth, 6% (2/33) individuals had lost four teeth. In males 17% (10/60) had lost one tooth, similar number of individuals – 5% (3/60) had lost three and four teeth, 7% (4/60) had lost five teeth and similar number 2% (2/60) had lost six, eight, nine and 11 teeth. In undetermined sex group 22% (2/9) of individuals had lost one tooth, similar number of individuals – 11% (1/9) had lost three, four and nine teeth (Fig. 32).
In Late Bronze Age only 29% (2/7) females had lost one tooth, 12% (2/17) males had lost one tooth, similar number of individuals – 6% (1/17) had lost two, five, six, eight and nine teeth. No undetermined individuals were observed with the condition. In Antique period similar number of females – 8% (1/12) had lost one, three, four and five teeth, 20% (4/20) males had lost one tooth, similar number 10% (2/20) had lost two, three, five and 11 teeth and similar number of individuals of undetermined group – 33% (1/3) had lost one and nine teeth. In Early Middle Ages 7% (1/14) of females had lost four teeth, 17% (4/23) of males had lost one tooth, similar number 2% (1/23) had lost three and five teeth, and 9% (2/23) males had lost four teeth. Similar number 20% (1/5) of individuals in undetermined group had lost one, three and four teeth (Fig. 33).

**Figure 32. Percentage of severity of AMTL between sex**
5.5.4 Calculus

Calculus was observed on 40% (10/25) of individuals in Late Bronze Age, on 31% (11/35) of individuals in Antique period and on 45% (19/42) of individuals in Early Middle Ages (Fig. 34). Statistical comparison in prevalence of calculus between time-periods did not reveal any significant changes (chi-square, p=0.464). Dental plaque was detected on 21% (7/33) of females whereas 45% (27/60) of males were observed with the condition. In undetermined sex group 67% (6/9) had calculus (Fig. 35). The comparison of prevalence of dental plaque between sex, statistically was significant (chi-square, p=0.017). In Late Bronze Age calculus was detected on 29% (2/7) of females, 41% (7/17) of males and 100% (1/1) individual from undetermined sex group. In Antique period the condition was observed on 17% (2/12) of females, 40% (8/20) of males and on 33% (1/3) of undetermined individual. In Early Middle Ages 21% (3/14) of females, 52% (12/23) of males and 80% (4/5) of undetermined individual had calculus (Fig. 36). These results showed that the prevalence of calculus was greater in males than in females.
Figure 34. Percentage of prevalence of calculus across time-periods

Figure 35. Percentage of prevalence of calculus between sex
From the results it can be summarised that there is: (1) a decrease of carious lesions and abscesses over time; (2) a greater number of AMTL in the Antique period; (3) a greater prevalence of calculus in Early Middle Ages (Fig. 37); (4) a greater number of females with carious lesions (5) a higher frequency of abscesses in females; (6) a greater distribution of AMTL and calculus in males (Fig. 38).
5.6 Discussion

As was the case for porotic hyperostosis, dental samples used in this research may not be completely representative of the whole population of the greater Mtskheta region in all three of the time periods. However, the pathologies observed on these dental samples do provide a potential snapshot that is reflective of the population’s diet and its related questions in this region. The significant trends among dental pathologies, suggest that there were changes in oral health from the Late Bronze Age, through the Antique period and in to Early Middle ages. Somewhat surprisingly, caries and periapical disease decreased over time, but antemortem tooth loss and calculus increased in Antique period but decreased in Early Middle Ages, whereas calculus decreased in Antique period and increases in Early Middle Ages. Prevalence of carious lesions and periapical lesions is greater in females than in males, but interestingly antemortem tooth loss and calculus were greater in males than in females.

As was discussed in previous chapters, the cause of caries lesions within a population can be associated with the consumption of food rich in hydro-carbonates such as different type of grains, which is directly connected to agricultural activates. Caries lesions observed among the Late Bronze Age population of Mtskheta likely reflects their agro-pastoral activities.
Consistent with this, excavations of the Late Bronze Age Samtavro and Treli archaeological sites provide evidence for agricultural activities such as sickles for harvesting grains and grinding stones for grain processing, together with domestic animal bones at these settlements (Giunashvili, 2018). The most striking evidence of grain consumption are ovens for backing found almost in every house at Samtavro settlement (Giunashvili, 2018).

The slight decrease of caries lesions in the following Antique period may be related to urbanisation. Studies on modern urban centres demonstrates that urbanisation is often accompanied by a shift in economic activity, from agriculture to industry and increased activity in trade (Satterthwaite et al., 2010). In addition, studies in modern Asia countries show that the changes of economic activities in urban settlements, are accompanied by lower consumption of cereals than in rural settlements. By contrast, consumption of meat, fish, vegetable, and fruit is much higher in urban than in rural settlements. For example, in urban areas of Indonesia, Vietnam, Bangladesh, and Nepal, the rate of cereal consumption is 26% compared to 37% in rural areas. This differences in consumption is linked to the change of lifestyle that is usually associated with the emergence of urbanisation (Reardon et al., 2014). A similar correlation may have occurred in the greater Mtskehta region during the transition from agricultural to more urbanised settlements. The introduction of urbanisation is also associated with the establishment of active trade routes with surrounding regions and the development of craftsmanship. As a result, the economy became more diverse and was less dependent on agriculture or pastoralism. Subsequently the ratio of carbohydrate-rich food in the diet, which is one of the primary causes of caries lesions, decreased. It is likely that this process continued in the subsequent Early Middle Ages, when urbanisation in Mtskheta reached its peak.

Consistent with the strong relationship between caries and dental abscesses (Dias, 1997), the prevalence of abscesses also decreased in the Mtskheta region during this time. The highest rates of abscesses were detected in Late Bronze Age and decreased in the later periods (Antique period, Early Middle Ages), as it is known it appears secondary to caries, trauma and unsuccessful root treatment.

Antemortem tooth loss may provide an important insight regarding the pattern of behaviour of past populations. Possible causes for antemortem tooth loss may include the consistency of food (i.e. its toughness, that can be a reason for dental wear or caries), food preparation methods, dental surgery for ritual or aesthetic reasons and traumatic injury. For example, studies of the ancient inhabitants of Tenerife in the Canary Archipelago, showed that
antemortem tooth loss was much more prevalent in males than in females (Lukacs, 2007). A similarly increased prevalence of post-mortem tooth loss amongst males was detected in the Mtskheta region population. At this stage, the reason for this increased prevalence among males is not clear. However, one possibility is that changes in diet may have led to increased accumulation of dental calculus with concomitant increases in caries, gingivitis and gum disease leading to loss of teeth. Intriguingly there was a significant trend for more prevalent calculus in males than in females over the three periods. This suggests that males may have had a different diet or perhaps had poorer dental hygiene than females. In the next chapters I investigate the dental calculus and the oral microbiome in the skeletal remains obtained from Mtskheta.
Chapter VI: Oral microbiome – calculus

The human oral microbiome contains more than 2000 bacterial taxa, along with innumerable pathogens that can cause periodontal, respiratory, cardiovascular and systemic diseases (Warinner et al., 2014). The human oral microbiome provides significant information on the evolution of and interaction between the human microbiome and the health and diet of the host. The oral microbiome is comparable with gut microbial communities, in that it varies based on diet, hygiene and environmental practices and, accordingly, produces specific cultural signals (Weyrich et al., 2015b).

For archaeological material the main source of information about the oral microbiome is dental calculus as it is the most precise fossilised record of bacterial communities (Weyrich et al., 2015b). Dental calculus is a complex, mineralised bacterial biofilm. It is formed by dental plaque, saliva and gingival inflammatory exudate (De la Fuente et al., 2013; Warinner, Speller, Collins, et al., 2015; Weyrich et al., 2015a). Two forms of calculus may be distinguished - supra and sub-gingival, depending on the location on the tooth of the exposed calculus (Waldron, 2009). Usually calculus accumulates faster where there is a high protein and carbohydrate diet, which supports an alkaline oral environment (Roberts & Manchester, 2010). Calculus mostly accumulates on the lingual surfaces of the anterior teeth, because this area is the most alkaline zone in the mouth (Waldron, 2009).

6.1 Methods and Materials

For this study, calculus samples were analysed from the shellac-free osteological materials for 31 individuals from all three time periods. Even though calculus samples were taken from all teeth on which calculus was detected, only calculus from molar and premolar teeth were analyzed to limit the impacts of oral geography on the resulting microbiome signal. The analysed calculus samples were compared to the molar calculus of ancient Europeans (Weyrich, 2017) and modern Americans (Human_Microbiome_Project_Consortium, 2012) .

Dental calculus was evaluated and recorded by the degree of formation, occurrence, and location on the teeth. There are three degrees of formation: Degree 1 - small amount,
Degree 2 - moderate amount, Degree 3 - large amount (Bothwell, 1995). The occurrence documented position in the oral cavity: buccal, labial and interproximal and location to its relative position on the tooth: supragingival and subgingival (Figure 21).

6.2 Sampling

For calculus analysis, the tooth and calculus must be separated from one another. Sterile dental tools, gloves, aluminum foil and small zip-log bags were used to collect the calculus samples as described previously (Weyrich et al., 2015a). Clean, fresh aluminum foil was placed under the teeth featuring calculus (to catch the calculus if it fell off the tooth surface and onto the bench top), and a small amount of pressure was applied to the calculus using a dental tool and dislodged calculus samples were placed collected directly into plastic bags positioned beneath the tooth. For each new sample, the aluminum foil was changed to avoid contamination with the previous sample. In addition to the skeletal information for each individual, key information about the sample (e.g. which tooth the sample originated from, the degree of calculus formation, occurrence, location, specimen number, name of institution where the sample was collected, and the date of sampling) was also collected. The samples were then

Figure 39. Degrees of formation of calculus: Mandible left side. Tooth P1 – Degree1/labial/supragingival; P2 - Degree2/labial/supragingival; M1 – Degree3/labial/supragingival
shipped to the University of Adelaide, Australia for analysis in the Australian Centre for Ancient DNA.

DNA was extracted using an in-house silica based method (Weyrich, 2017) for preparation of DNA sequencing libraries Kircher et al. (2012), as described previously. Both extraction blank controls and no-template amplification controls were included at a ratio of 1:10 (control:samples) to assess laboratory DNA background levels. All DNA libraries were cleaned using Ampure and were quantified using a TapeStation and by quantitative PCR (KAPA kit). DNA libraries were sequenced on an Illumina NextSeq using a 300 cycle, paired-end kit.

DNA sequences were trimmed, quality filtered, and demultiplexed using AdapterRemoval2, and only overlapping DNA sequences from the paired-end sequencing were retained (10 bp overlap). The resulting sequences were identified using MALTx, by comparing DNA sequences against the 2014 NCBI non-redundant database with default parameters, as described previously (Weyrich, 2017). Data was then imported into MEGAN6 (v 6.11.2) using default LCA parameters (Caporaso et al., 2010; Herbig et al., 2016; Huson et al., 2016), Alpha (Shannon’s) and beta-diversity (Bray Curtis) were calculated and visualized in MEGAN6 on data normalized to the lowest sample number (376,035 sequences per sample). Assessments of community structure, species abundances, and filtering of contaminant species was also conducted in MEGAN6; any species identified within extraction blank or non-template library negative controls was removed from the generated data. Statistical comparisons, including Kruskal Wallis (to identify significantly different species) and PERMANOVA (to identify significantly diversity) were calculated in QIIME1 (v 1.9.1) (Caporaso et al., 2010).

In total, 34 calculus samples were analyzed from 20 individuals: 5 individuals with 8 calculus samples from the Late Bronze Age; 5 individuals with 6 calculus samples from the Antique period; and 10 individuals with 20 calculus samples from the Early Middle Ages. The average depth of sequencing was 1.71 million identified sequences per sample of the Georgian materials. These were compared to modern Americans (avg. sequencing depth of 1.19 million per sample) and to Ancient Europeans (avg. 715,908 sequences per sample) (Table 7).

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Table 7. The depth of sequencing of all the materials

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6.3 Results

We first used beta-diversity analysis to assess the preservation of an oral microbiome signal within the samples; we constructed a PCoA plot of Bray Curtis differences. Several samples were noticeably different compared to other ancient and modern calculus samples, as they clustered with laboratory controls. This trend typically signifies a lack of oral microbiome
signal and likely poor preservation (Figure 40). Three samples (A20355; A20354; A20356) were excluded from downstream analysis.

From the 20 remaining individuals included in the study, we examined the microbial phyla observed (Figure 41). The major phyla are similar to those found in the modern oral cavity, including Firmicutes, Actinobacteria, Fusobacteria, Bacteriodetes, and Proteobacteria, signalling the robust preservation of an oral microbial environment.
Figure 40. Beta diversity: between sample diversity
We then compared the oral microbiome in the pre- and post-urbanised communities. The oral microbiome in pre (Late Bronze Age) and post (Antique period and Early Middle Ages) urbanised state societies were significantly different, suggesting that the oral microbiome did change over the time. PERMANOVA test showed significant difference between pre and post urbanised state societies (p=<0.01; pseudo F = 40).

We then investigated the bacterial species that could drive these differences. There were several species that underlie this difference between pre- and urbanised communities. *Treponema* and *Tannerella* species, which are associated with periodontal disease and inflammation (Holt & Ebersole, 2000), were higher in urbanised samples than those in pre-urbanised communities (Table 8). In addition, *Prevotella* species decrease over the time in Georgia. As *Prevotella* species can be linked to inflammation, this may signify differences in health status over time in Georgia.

<table>
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<th>Post Urbanised Mean</th>
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<td>0.01</td>
<td>1.44</td>
<td>4.65</td>
<td>o__Campylobacterales</td>
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</table>
Table 8. Statistics of pre and urbanised state societies

We also explored species linked to dental caries in this population. *Streptococcus mutans*, a known main factor of caries in Middle Ages and modern European populations, is absent in Georgian calculus, including those with caries. Instead, *Streptococcus* sp. DD04 was present, although it is not commonly observed in modern people, and little is known about its role in caries formation. There were also several additional differences between European and modern populations compared to ancient Georgians. In Georgian materials, there was an observed lack of *Veilonella* species, which can be linked to food fermentation. Interestingly, the bridging microorganisms linked to mature dental calculus formation, *Fusobacterium* and *Leptotrichia* species, are widely present in Georgian materials, similar to observations in ancient agriculturalist Europeans, suggesting that plaque formation in Georgian populations may be similar to that of ancient Europeans that consumed large quantities of carbohydrates. Notably, *Methanobrevibacter* species – oral archaea common in ancient Europe – were also common in Georgian samples.

The oral microbiome analysis of Georgian dental calculus demonstrates that the oral microbiome changed over the time. Although some similarities were observed between the oral microbiomes of ancient Europeans and Georgians, some specific bacteria in Georgian materials were not present in modern people or were different from ancient Europeans.
6. 4 Discussion

The results of analysis of ancient Georgian dental calculus showed that the oral microbiome changed over time. There was a significant difference between pre urbanised (Late Bronze Age) and urbanised (Antique period and Early Middle Ages) period. Although there were some similarities between the oral bacteria identified within ancient European and Georgian materials, there were some specific bacteria in Georgian materials that were not present in modern people or were different when compared to ancient Europeans. Most of the bacteria found in Georgian sample are connected to periodontal disease and inflammatory processes.

Despite these minor differences, ancient plaque in Europe and Georgia was relatively similar. Notably, both ancient cultures shared the presence of *Methanobrevibacter*, which was common in the ancient Georgian samples. *Methanobrevibacter* is an anaerobic archaea that produces methane, and different *Methanobrevibacter* species are found in intestine and in oral cavity of humans (Balch et al., 1979). While it is known that the form and function of members of this species of archaea are very diverse, they are not linked to cause of diseases. Intriguingly, in patients with severe periodontal diseases, this species was abundant (Lepp, 2004).

Our intention to check oral microbiome of Georgian samples for the specific bacteria of Georgian wine, honey and wheat was not successful. As recent studies show the earliest evidence of grape wine and viniculture (dated to Early Neolithic - ca.6,000-5,000 BC) and honey (dated to the VI millennia BC) (Kvavadze, 2014; McGovern, 2017) was on territory of Georgia. Out of 20 wheat species known in the world, 14 were cultivated in Georgia and five of them are native to Georgia - endemics (Jorjadze, 2014). Even though there are number of studies about Georgian wine, honey and wheat, unfortunately there are few studies about bacteria, especially the kind of bacteria that are specific to each of these products. So, to test whether people from Late Bronze Age to Early Middle Ages at Mtskheta region were consuming those products was impossible due to lack of microbiological studies on this topic. Also, oral microbiome was not tested for the intestine parasitic diseases.
Chapter VII: General Discussion and Conclusion

The results of this study further this notion, as there are a few significant differences for various skeletal pathologies indicating health status and lifestyle suggests that population of Mtskheta region from pre-urban (Late Bronze Age) to urban (Antique period, Early Middle Ages) experienced stress.

The following will discuss the results of statistical analysis of palaeopathological and dental calculus analyses and will be incorporated in order to understand how they fit together and support or contradict the research question. These results will be also interpreted in the context of archaeological and biocultural evidence. Throughout the period of the Late Bronze Age to the Early Middle Ages archaeological and historical investigations in Mtskheta show important socio-economic and cultural changes, among which two elements are the most conspicuous: 1) The emergence of state society that is reflected in the establishment of Iberian kingdom with socially highly stratified population; 2) Urbanisation, which is associated with the formation of large settlements, defined planning, administrative buildings, craft workshops and trading places (Apakidze, 1963; Kipiani, 2010b; Nikolaishvili, 2005). These significant social and historical events in the modern territory of eastern Georgia are dated to the 5th c. BC - 4th c. AD (Nikolaishvili, 2005). The important questions that I sought to address in this thesis were: 1) to what degree did the emergence of the complex state society and urbanisation affected the health of the population of Mtskheta relative to that in the pre-urban Late Bronze Age, and 2) how emergence of urbanisation affected the diet of the population of Mtskheta region?

7.1 Urbanisation and the deterioration of population health

The results of this study revealed several significant differences and trends for different skeletal indicators of health and diet, which suggest that the socio-political changes and progress of urbanisation from the Late Bronze Age to the Early Middle Ages had significant impacts on population health.
7.1.2 Porotic hyperostosis

As described in chapters 4 to 6, there were three major significant trends indicating changes in health status of the population across the three historical periods: 1) there was a greater prevalence of porotic lesions 2) there was an increase in prevalence of porotic hyperostosis in females compared to males, and 3) an increase in prevalence of healed lesions. As the etiology of porotic hyperostosis suggests that bone marrow hyperplasia is usually a response to iron deficiency anaemia (Bothwell, 1995; Ortner, 2003; Stuart-Macadam, 1998; Stuart-Macadam, 1985; Walker, Rhonda, et al., 2009; Walker, Bathurst, et al., 2009) it is reasonable to assume that the increased prevalence of porotic hyperostosis may be due to iron deficiency anaemia. However, it has also been suggested iron deficiency anaemia should be considered as a symptom caused by a poor diet, poor iron absorption, infections or blood loss and not necessarily as a disease per se (Stuart-Macadam (1998)).

The data obtained in this study is supported by a previous paleopathological study of skeletal materials from Georgia. An examination of skeletal material from Doglaura cemetery (Georgia), which belongs to the Samtavro archaeological culture, revealed a high frequency of cribra orbitalia (Bertoldi, 2016). While in the bioarchaeological literature porotic hyperostosis and cribra orbitalia are both considered to be caused by iron deficiency anaemia (Rivera, 2017), the precise relationship between lesions of cribra orbitalia and porotic hyperostosis is not completely understood. It is suggested that cribra orbitalia is an early sign of porotic hyperostosis, whereas porotic lesions on the cranial vault indicate longer term anaemia (Stuart-Macadam, 1998; Stuart-Macadam, 1985; Suby, 2014; Walker, 1986).

The greater prevalence of the porotic hyperostosis lesions in females may be connected with prolonged breastfeeding, which can be a risk for vitamin B12 deficiency and thus cause of anaemia (Walker, Bathurst, et al., 2009; Weiss, 2004). At this stage there is no clear evidence that this was a normal cultural practice in Georgia at that time and thus remains a speculation.

While at this stage, defining explanations for this increase in porotic hyperostosis in Mtskheta may be speculative it is highly likely that it may be related to two factors, infections and diet, which were affected by the increasing urbanisation of Mtskheta society. The first factor of infection is directly associated with the dramatic increases in population density and the consequent poor sanitation, which creates a perfect ground for the spread of infection. The second factor of diet can be linked to social hierarchization and political instability when
certain categories of people within the population had limited access to the food and may have suffered from malnutrition. Both factors are connected to anaemia that is responsible for porotic lesions. Below we discuss both conditions in the context of the Greater Mtskheta region.

7.1.2 Urbanisation, poor sanitation and epidemics

Mtskheta, which meets all the requirement of a Roman type city in the Antique period could have had sanitation problems, despite its natural environment with numerous small tributaries to Kura and Aragvi Rivers that served as a natural sanitation for the city. We postulate that poor sanitation conditions in Mtskheta would have resulted in increased outbreaks of epidemics and that its dense population could facilitate its rapid spread. Such epidemics could be responsible for iron-deficiency among Antique period populations in Mtskheta. As already mentioned, there are no palaeopathological studies in context of urbanisation in Georgia, we have to compare this study or to give an example of the link between viral infections and iron deficiency anaemia. To test dental calculus on viral infections was impossible, usually viruses are not trapped in dental plaque. We cannot rule out the existence of viral infections in Mtskheta during the period of urbanisation. But in literature there is an example where is shown the link between porotic lesions and specific infection type, it was 17th–19th century skeletons of indigenous South Africans from densely populated areas. In this study, that also involved DNA analysis, association of porotic hyperostosis with smallpox was proposed (Peckmann, 2003).

A disease known as Antonine Plague in 165–180 AD in the Roman Empire is described as being accompanied by high fever, diarrhea and skin eruptions. Many specialists connect this to smallpox or chickenpox (McNeill, 1976). These diseases were brought into the Roman territory by solders from the Near East military campaigns. We know that during the Roman – Parthian war in Armenia, there was an epidemic of Antonine Plague among the Roman soldiers that influenced the result of the war (Bruun, 2007). The scale of the Antonine Plague in the Near East was not as large as it was in the Roman empire, where it dramatically affected the demography of the Roman empire. It is plausible that densely populated Mtskheta, which in the Antique period had close interactions with neighbouring regions, was also affected by the
Antonine Plague. Similar to the Near East, it may not have been to the scale of the epidemic in the Roman Empire.

An example of a bioarchaeological study that relied on the incidence of porotic hyperostosis to understand the impact of urbanisation on a population’s health is the Medieval skeletal material from Poland. In this study material from three time periods – Pre-urbanisation, Early urbanisation and Late urbanisation were compared to each other. Similar to our results, statistical examination of porotic hyperostosis did not show significant differences between the Pre-Urbanisation and Urbanisation periods in Poland. Cox proportional hazards and Kaplan Meier survival analysis of these materials demonstrated that general health and risk of death deteriorated significantly with the emergence of urbanisation (Betsinger, 2007a; Betsinger & DeWitte, 2017). Similar findings were obtained, when the pre-urbanisation and urbanisation periods were studied in Britain. Using porotic hyperostosis as an indicator of health, it was concluded that in the Roman period, the health of populations in urban areas began to deteriorate (Redfern & DeWitte, 2011).

From the period of the Late Bronze Age to the Early Middle Ages covered in this study Mtskheta was gradually changing from rural settlement into a complex urban society. Parallel to this, we find an augmentation in the number of people suffering from the results of urbanisation in Mtskheta. That there is evidence of porotic hyperostosis in the Late Bronze Age rural society of Mtskheta should not be surprising. Studies on modern populations demonstrate that anaemia is more frequent among pastoral populations, as they are at high risk of zoonotic anaemia-causing parasitic vectors such as intestinal worms, hookworms, Ascaris and Trichurus; (Bechir, 2014). These parasitic worms are transmitted from cattle to humans causing intestinal blood loss that often results in anaemia (Stoltzfus et al., 1997). The agro-pastoral society of Mtskheta could have been at high risk from these parasitic diseases as in the Late Bronze Age settlement of Samtavro, single cell houses had a special place for keeping cattle (Giunashvili, 1979). In such circumstances, where people and domestic animals lived in the same house parasitic worms could easily be transmitted from animals to humans.

Using an analysis of dental calculus, we attempted to check the presence of all the microorganisms, bacteria, of the known diseases in urbanisation period. We checked for all known pathogens causing diseases such as Brucellosis (B. abortus, B. canis, B. melitensis, B. suis), Q fever (Coxiella burnetti), Anthrax (Bacillus anthrasis), Tuberculosis (Mycobacterium
tuberculosis), scrub typhus (Oriental tsutsugamushi). However, none of these were identified. Several sequences to *Bacillus* were found but to non-pathogenic species. It is also important to note that bridging organisms on dental calculus are resistant to other pathogens attaching to the calculus. Thus, unless the disease burden of the individual was significant, we may not be able to pick it up with dental calculus. As it was not possible in practice to detect viral infections through dental calculus, I cannot rule out that some viral infections such as smallpox, chicken pox, measles, mumps, etc. were related to the increase in the incidence of porotic hyperostosis through time.

One of the causes of anaemia can be a zoonotic disease. It was common in agricultural society for animals to be kept inside houses (Latham, 2013) and thus facilitate the spread of zoonotic diseases from animals to humans (Eshad, 2004). Gastrointestinal parasites can be transmitted from contaminated water, soil and food (Slifko, 2000). The most common parasitic vectors that cause zoonotic anaemia are intestinal worms, hookworms, *Ascaris* and *Trichuris*; (Bechir, 2014). These parasitic worms are transmitted from cattle to humans causing intestinal blood loss, as well as vitamin B12 deficiency that results in anaemia (Stoltzfus et al., 1997).

### 7.1.3 Social hierarchization and malnutrition

According to archaeological evidence in urban period in Mtskheta was social hierarchization and inequality. Socially higher class people were privileged to have their own bathes - Roman type bathes, located in Royal residences, and thus socially different class people had different access to running water and private toilets (Nikolaishvili, 2005). By contrast, lower class populations likely obtained water from public places and used public toilets and baths and thus their hygiene conditions may have been poorer than upper class populations, making them more vulnerable to epidemic diseases leading to anaemia. Besides problems related to hygiene, we suggest that lower class populations such as slaves or farmers in Mtskheta who depended entirely on agricultural products had limited access to animal products and may have been more prone to iron-deficiency anaemia. Consistent with this, it has been demonstrated in modern population - children under 6-years of age, or children whose mothers do not consume red meat during pregnancy or lactation are at high risk of anaemia (Moshe, 2013). Meat is not only rich in iron but also in vitamin B12. Low levels of both elements are considered to be responsible for anaemia (Walker, Rhonda, et al., 2009; Walker,
Another contributor to malnutrition of the population in Mtskheta was that the Early Medieval period was characterised by intensive warfare, which resulted in the collapse of the Kartli kingdom. The extended period of political stability would likely have depleted food reserves and the resultant economic stagnation could have influenced negatively the economic situation of particularly the lower classes of the population and their access to certain types of food. An interesting investigation in this regard was done on the skeletal material from Croatia, on the eastern Adriatic coast, where the oral health of individuals from the Late Antique period of the Roman Empire were compared with those from the Early Medieval period after the collapse of Roman empire. Results showed that after the collapse the Roman empire and the accompanying increased warfare, adversely affected the health of the population (Laus et al., 2011).

We observed significant differences between the Late Bronze Age, Antique period and Early Middle Ages in the frequency of healed lesions. Active lesions indicate that the disease was present at death, whereas healed lesions suggest that the individual recovered from the disease before death (Grauer, 1993). The absence of healed lesions among the Late Bronze Age population suggests that in this period, individuals with porotic lesions did not recover and that the underlying disease was fatal. The occurrence of healed lesions in the subsequent periods suggests that the people from the Mtskheta area obtained immunity to certain infections or for other reasons were capable of overcoming the underlying disease processes. Even though transition to urban living has its negative effect on population’s health by increased diseases, it might be expected in longer term urbanised people to have an increased disease resistant, that can be similar to natural selection (Barnes et al., 2011).

The occurrence of healed porotic lesions in Mtskheta may also be connected to the development of medicine in the Antique period. There is some evidence for medicine in the Greater Mtskheta region in this period. Palynological examination of glass bottles found at the Samtavro cemetery show the use of different type of herbs for medicinal purposes (Kvavadze, 2018). There is also some indication of specific vessels for medicine in the Greek mythology of the Argonauts, where we know that in dark night Colchian Media was collecting the extract from Prometheus herbs in the shell (Kaukhchishvili, 1964). Population in Antique and Early Medieval period in Mtskheta, who were detected with the degree of active porotic lesion at the period of their death, might suffered from iron deficiency, that probably was reflected on their physical development including difficulties of development cognitive skills (Murray-Kolb, 2013; Walter, 2003).
7.2 Dental health

7.2.1 Urbanisation and diet change

From the results it can be summarised that there is: (1) a decrease of carious lesions and abscesses over time; (2) a greater number of AMTL in Antique period; (3) a greater number of calculus in Early Middle Ages; (4) a greater number of females with carious lesions (5) a higher frequency in females of abscesses; (6) a greater distribution of AMTL and calculus in males.

One of the key oral health indicators of diet change is caries, the frequency of which is associated with the consumption of high-carbohydrate agricultural foods such as different type of grains (Houte, 1994; Larsen, 2006). As with porotic hyperostosis, there were no significant differences in prevalence of caries lesions over time in the greater Mtskheta region. However, compared to Late Bronze Age, the frequency of caries decreased in the Antique period and Early Middle Ages, and there was a significant trend of decreasing prevalence of lesions over the three time periods and, intriguingly, females exhibited more carious lesions than males.

Generally, the presence of caries among the Mtskheta population from the Late Bronze Age to Early Medieval period may be correlated with the intensive agricultural activity that emerges in this region (Kartli region) from VI millennium BC (Kvavadze, 2014) and continues in the Late Bronze Age. Previous archaeological studies have indicated that caries is mainly characteristic for sedentary populations with agriculture activities (Hillson, 2001). It is caused by foods high in carbohydrates, which were introduced with the onset of agriculture in the Neolithic period, such as cereals, dried fruits, flour and bread products (Adler et al., 2013; Larsen, 1997; Warinner, Speller, Collins, et al., 2015; Weyrich et al., 2015a). Based on the evidence of results of isotopic examination from the Treligorebi settlement located 10 km from Mtskheta, cereal played an important role in the diet of the Samtavro culture population in the Late Bronze Age (Herrscher et al., 2014). Palynological analysis has revealed that diet of the population of Kartli region from VI millennium BC with meat (pork, beef) was consisting of grains (mostly wheat, different types), legumes, nettle (which is still a part of a diet in Georgia), poppy, walnut, hazelnut, grapes, strawberries and other herbs (Kvavadze, 2014).

With the emergence of urbanisation during the Antique period, we observe the intensification of agricultural activities, which were mainly caused by the introduction of new agricultural tools made from iron (e.g. the plough) and irrigation systems. The increased efficiency in agricultural production that these innovations provided, likely resulted in increased consumption of agricultural products rich in carbohydrates, and subsequently
increased prevalence of carious lesions among the urban population.

This increased productivity also led to the development of trade and local craftsmanship, which diversified the economy of the Iberian kingdom. Compared to the Late Bronze Age, where the population consisted mostly of farmers, in later periods with the diversification of the economy and the development of craftsmanship, the economy of Mtskheta was less dependent on agricultural or pastoral activities. This may mean that in the urbanisation period, the ratio of cereal products in the diet decreased. This is reflected in the frequency of caries lesions being less in subsequent periods compared to the Late Bronze Age.

Another theory to explain the lower frequency of caries lesions in Urban society is the consumption of milk products. Various studies demonstrate that milk and yogurt can result in the decrease of caries among populations (Nikawa, 2011; Petti, 2008). In vitro study of effect of isolated lactobacilli on oral pathogens showed that edible yogurt that contains *Lactobacillus rhamnosus* L8020 significantly reduce the risk of caries and periodontal diseases (Nikawa, 2011). From this perspective we can speculate that increase of dental caries over the time in Mtskheta population can be linked to one of the Georgian traditional dairy products–Matsoni. Study of lactic acid bacteria from Matsoni (total of 26 samples) showed that out of isolated 80 strains of lactic acid cocci and 173 strains of lactobacilli, the predominant in 25 samples were *Streptococcus thermophilus* and *Lactobacillus delbrueckii* spp. *Bulgaricus*, in one sample of Matsoni with those species was found *Lactobacillus helveticus*. This study showed that there was a diversity of *S. thermophilus* and *L. delbrueckii* spp. *bulgaricus* in the strain level (Uchida, 2007). Although in Matsoni was not found *Lactobacillus rhamnosus* which is known is linked to decrease of *S. mutans* in oral microbiome, it is likely that numerous Lactobacilli that contains Matsoni could be a reason of decreasing caries over the time in Georgia.

On balance, the analyses of caries lesions of Mtskheta population from the Late Bronze Age to Early Middle Ages, combined with the analyses of other pathologies, suggest that the diet of the population in Greater Mtskheta became increasingly diversified with the emergence of urbanisation. While the ratio of grain products increased with the advent of agriculture in the Late Bronze Age, it is likely decreased in Antique and Early Medieval period as cereal consumption was balanced by other non-grain products, possibly - meat, fish and vegetable.

Somewhat surprisingly, the comparison of caries lesions among female and male individuals showed significant that females in Mtskheta had a greater prevalence in both the pre-urbanisation and urbanisation periods suggesting that the diet differed between genders.
Some evidence in support of this comes from early Georgian literature, dated approximately to 476-483 AD in *The Martyrdom of the Holy Queen Shushanik*, there are descriptions of life in these times and from this text it is apparent that men and women did not eat together in Kartlian kingdom (Tsurtaveli, 2012). This raises the possibility that they may also have had very different diets and provides a potential insight into gender and status-based access to food. Similarly, it is known that at the Classical Maya site of Calakmul dated to the 250-900 AD, females from higher social groups had much higher number of caries than males, whereas in lower social classes, both genders had the same rate of caries. This was interpreted to indicate that elite male food consumption was based more on animal protein and that elite female food included a greater consumption of carbohydrates that caused caries (Cucina & Tiesler, 2003). It should be noted, however, that in general, the incidence of caries is higher in females than males (Lukacs & Largaespada, 2006) and is linked to hormonal changes related to pregnancy that can compromise the immune system of females (Ferraro & Vieira, 2010; Lukacs & Largaespada, 2006).

Despite females having a greater incidence of caries, males had a greater percentage ante mortem loss of teeth (AMTL). It is unclear whether this difference is due to male rituals involving tooth removal or whether this represents differential nutrition or access to rudimentary dental surgery to remove teeth with caries or because of abscesses (Lukacs, 2007). Another possibility is that this increased ante mortem loss of teeth in males represents differential susceptibility to tooth decay as happens in Lemierre’s disease (see below).

Our analysis of dental calculus from the Georgian teeth samples identified bacterial species that commonly cause abscesses (Farrer, 2018), such as *Treponema*, *Tanerella* with the bridging organisms, *Fusobacterium* and *Leptotrichia*. The potential of dental abscesses to be a reason of spreading sepsis and even death was known from the Antique period. In the 1600s, mortality records list “teeth” as the 5th or 6th leading cause of death (Robertson & Smith, 2009). Periodontal disease can also cause Lemierre’s syndrome, a rare disease that usually affects young and healthy men (Cheung & Bellas, 2007). *Leptotrichia* can be a cause of many infectious and tumorous processes, but it can also contribute to tooth decay (Eribe & Olsen, 2007). Despite the presence of caries in many of the samples, no *Streptococcus mutans* was identified in Georgian calculus samples. We assume that the tooth decay in Georgian teeth may have been initiated by *Leptotrichia*, which can also be involved in the development of abscesses. Furthermore, *Prevotella* can be a responsible for abscess development and related inflammation in Georgian populations. *Treponema* and *Tanerella* found in Georgian materials,
together with Porphyromonas gingivalis, are also considered to be the three periodontal pathogens (Byrne et al., 2013). This suggests that the bacteria and pathogens required to cause inflammatory oral disease were present in ancient Georgian individuals, although the factors that underpin these diseases in these populations remain unknown.

The significant difference of the prevalence of calculus between males and females may be linked to diet. High rate of calculus shown in the study may be associated to the increased oral alkalinity, due to protein rich diet. At the same time it also may be linked to high consumption of carbohydrates (Lieverse, 1999; Lillie, 1996).

Conclusion

Our overall results help us to summarize the information about paleopathology in Georgia. The observation of pathological lesions such as porotic hyperostosis, dental pathologies as well as examination of dental calculus contributes to the studies of urbanisation in general. It allows us to see how the emergence of urbanisation affects the health of a population along with a change diet. This study indicates that in the Mtskheta region, changes associated with the urbanisation were gradual. The deterioration of health and change in diet was happening alongside the growth of urbanisation, which lasted for a long period from around 4th centuries BC to 6th centuries AD. The gradual deterioration of health might be connected to poor sanitation associated with urbanisation. It was fertile ground for the exposure of infectious diseases, which was the likely cause of anaemia among the people of Greater Mtskheta. This was especially the case with the lower-class populations who had poorer sanitation than the elite society.

Dental health suggests that there was a change in diet associated with the emergence of urbanisation. Should could be linked to the diversification of the economy that is typical for urban places. Intensification of trade and the development of craft specializations made the urban economy less dependent on farming. This could have resulted in the diversification of diet of the population, where consumption of grain products decreased and was balanced by other non-grain products. This process was likely the cause of reduction of caries lesions among the populations in the Antique and Early Middle Ages.

That the process of urbanisation in Greater Mtskheta was gradual is also supported by the analysis on dental calculus analysis which showed that there were no radical changes in the oral microbiome over the time-periods. The only significant differences were detected between
pre and urbanised periods by the species of *Treponema* and *Tanerella* where there was a significant difference between Late Bronze Age and later periods. As it was discussed above these species suggest a potential increase in oral disease. However, observation on caries and abscesses shows that it does not coincide with these results. This suggests that further examination of dental material from Mtskheta region is needed to better understand the reason of these differences.

This research is the first attempt to provide insight into the impact of urbanisation on the health of the ancient population of Greater Mtskheta in the south Caucasus. To understand the consequence of urbanisation on health, porotic hyperostosis and dental pathologies were examined. The results of these examinations were combined with an analysis of dental calculus. The results suggest that urbanisation in Mtskheta was gradual and slow. It was initiated already in the Late Bronze Age and in Antique period it resulted in the formation of State society with capital town in Mtskheta. The impact of the urbanisation on the population’s health was adequate to this process and did not have severe effects. The frequency of porotic hyperostosis suggest that infectious diseases associated with urbanisation increased slowly over time and there was no significant difference between the pre-urbanisation and urbanisation periods. The same process can be observed in the frequency of carious lesions. It suggests that diet changed slightly with the emergence of urbanisation.

The samples studied here do not adequately represent the urban population of the whole Mtskheta, especially if we take into the consideration that it is impossible to determine if some of these individuals were born and raised in rural area and only died in Mtskheta. Future studies could benefit from examining samples from other urban areas in the Caucasus, as well as studying other pathological conditions such as degenerative joint diseases, trauma etc… This could provide more information on the professional activities, living conditions and warfare in the region that played an important role in the socio-economical processes. Dietary changes can also be examined through stable isotope analysis of carbon and nitrogen, which will provide important information to refine the conclusions of this thesis.


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