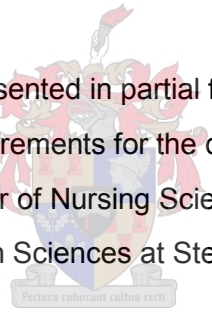
PREVALENCE OF MATERNAL TACHYCARDIA DURING LATE PREGNANCY

by Nicola Nel



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of the requirements for the degree of
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DECLARATION

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ABSTRACT

The importance of maintaining maternal wellbeing during the antenatal period is mandatory to the mother and the baby. Although asymptomatic maternal tachycardia could be seen as part of the physiological changes during pregnancy, it could also be a sign of a serious underlying condition. Previous studies have shown that maternal deaths could occur in women with pre-existing cardiac conditions (Naidoo, Desai & Moodley, 2002:17). The concern that many conditions associated with maternal tachycardia pass through the health care system without being noticed or investigated motivated the researcher to undertake this study.

The study aimed to determine the prevalence of maternal tachycardia during late pregnancy and its association with anaemia, major cardiac diseases and/or complications and adverse maternal and perinatal outcomes. A case-control retrospective study design within a prospective study was employed with a quantitative approach. A total sample size of 204 participants, constituting 14.3% of the study population (N=1431) was purposefully selected from the Monica AN24™ recordings of the Safe Passage Study at Tygerberg Hospital to collect the data. Ethical approval was obtained from the Health Research Ethics Committee of the Faculty of Medicine and Health Sciences, Stellenbosch University and a waiver of consent had been granted.

A group of 16 participants, who met the inclusion criteria, constituting 7.8% of the total sample, was selected for the pilot study. Reliability and validity was ensured by the pilot study and pre-testing the data collection instrument as it was tested under the exact circumstances as the actual study experts in the field of nursing and medical research and statistics were used. The data was analyzed by the use of the STATISTICA version 9 programme.

The results show a 7.1% (n=102) prevalence of maternal tachycardia in late pregnancy. There were no pre-existing cardiac conditions in any of the groups and no maternal cardiac complications during pregnancy and delivery. The case group had a higher incidence (55.0%) of haemoglobin values lower than 11.0 g/dL than the control group (47.0%), however the Mann-Whitney U test revealed no statistically significant difference of the Hb values at 28 to 38 weeks between the case and the control groups. The participants presenting with anaemia (Hb < 11.0 g/dL) were classified as mild anaemia (Hb value of 7.0 – 10.9 g/dL). There were no participants that presented

with severe anaemia (Hb value of < 7.0g/dL). There was an increased prevalence (9.1%) of infection in the participants presenting with maternal tachycardia, although this difference was not significant between the two groups. The infant outcome revealed an increased mean birth weight of 194g for the case group that presented with maternal tachycardia.

Several recommendations were identified that were grounded in the study findings. The findings reveal that the current antenatal care practice in terms of not recording the maternal heart rate is sufficient.

OPSOMMING

Die belangrikheid van die handhawing van moederlike welsyn gedurende die voorgeboorte tydperk is noodsaaklik vir die moeder en die baba. Alhoewel asimptomatiese moederlike tagikardie gesien kan word as deel van die fisiologiese veranderinge tydens swangerskap, kan dit ook 'n teken wees van 'n ernstige onderliggende toestand. Vorige studies het aangetoon dat moederlike sterftes kan voorkom in vroue met voorafgaande harttoestande (Naidoo, Desai & Moodley, 2002:17). Die kommer dat verskeie toestande wat verband hou met moederlike tagikardie, deur die gesondheidsorg stelsel kan deurglip sonder om opgemerk te word, het die navorser gemotiveer om hierdie studie te onderneem.

Die studie is daarop gemik om die voorkoms van moederlike tagikardie tydens laat swangerskap en sy verbintenis met anemie, ernstige hartsiektes en/of komplikasies en ongunstige moederlike en perinatale uitkoms te bepaal. 'n Gevalkontrole retrospektiewe studie-ontwerp binne 'n voornemende studie is gebruik met 'n kwantitatiewe benadering. 'n Totale steekproefgrootte van 204 deelnemers, wat 14.3% van die populasie (N=1431) uitmaak is op ‘n doelgerigte manier uitgekies uit die Monica AN24™ opnames van die Veilige Geboorte Studie by Tygerberg Hospitaal om die data in te samel. Etiese goedkeuring is verkry van die Mensnavorsing Etiese komitee komitee van Fakulteit van Geneeskunde en Gesondheidswetenskappe van die Universiteit Stellenbosch en 'n kwytskelding van toestemming is verleen.

'n Groep van 16 deelnemers, wat voldoen aan die insluitingskriteria, wat 7,8% van die totale steekproef bestaan, is geselekteer vir die loodsstudie. Betroubaarheid en geldigheid is verseker deur die loodsstudie en die voorafgaande toets van die data-insamelingsinstrument onder presies dieselfde omstandighede as die werklike studie sowel as die gebruik van kenners in die gebied van verpleging en mediese navorsing en statistiek. Die data is ontleed deur die gebruik van die Statistica weergawe 9 program.

Die resultate toon 'n 7,1% (n=102) voorkoms van moederlike tagikardie in laat swangerskap. Daar was geen onderliggende harttoestande in enige van die groepe en geen moederlike hartkomplikasies tydens swangerskap en geboorte nie. Die gevalgroep het 'n hoër voorkoms (55,0%) van Hb waardes laer as 11.0 g/dl as die kontrole groep (47.0%) gehad, maar die Mann-Whitney U-toets toon geen statisties beduidende verskil in die Hb waardes by 28-38 weke tussen die geval en die

kontrolegroepe nie. Die deelnemers met anemie (Hb < 11.0 g/dl) is geklassifiseer met ligte bloedarmoede (Hb waarde van 7.0-10.9 g/dl). Daar was geen deelnemers wat erge bloedarmoede (Hb waarde van < 7.0g/dL) getoon het nie. Daar was verhoogde voorkoms (9,1%) van infeksie in die deelnemers met moederlike tagikardie, hoewel die verskil nie beduidend tussen die twee groepe was nie. Die baba uitkoms toon 'n toename in gemiddelde geboortegewig van 194g vir die gevalgroep wat met moederlike tagikardie gediagnoseer is.

Verskeie aanbevelings is geïdentifiseer wat in die studie se bevindinge gegrond is. Die bevindinge dui daarop dat die huidige voorgeboortelike sorgpraktyk in terme van nie rekordering van die moederlike hartspoed voldoende is.

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ANC:	Antenatal Clinic (Pharmaceutical Medicine Dictionary, 2001) (see Excel Spreadsheet).
BANC:	Basic antenatal care handbook. (Pattinson, 2005).
BMI:	Body mass index (The Penguin Dictionary of Psychology, 2009).
BPM:	beats per minute (Jablonski's Dictionary of Medical Acronyms & Abbreviations, 2009).
CO:	Cardiac output (Jablonski's Dictionary of Medical Acronyms & Abbreviations, 2009).
CMACE:	Centre for Maternal and Child Enquiries (CMACE, 2006:149).
ECG:	Electrocardiogram (Monica AN24, 2009:1).
EDV:	end-diastolic volume (Jablonski's Dictionary of Medical Acronyms & Abbreviations, 2009).
ESV:	end-systolic volume (Jablonski's Dictionary of Medical Acronyms & Abbreviations, 2009).
GA:	Gestational age (Jablonski's Dictionary of Medical Acronyms & Abbreviations, 2009).
Hb:	Haemoglobin (Jablonski's Dictionary of Medical Acronyms & Abbreviations, 2009).
HIV:	Human immunodeficiency virus (The Human Body Book: An Illustrated Guide to Its Structure, Function and Disorders, 2009).
HR:	Heart rate (Jablonski's Dictionary of Medical Acronyms & Abbreviations, 2009).
IUD:	Intrauterine death (Easmin, Nahar, Jahan, Rahim, & Nila, 2011).
IUGR:	Intrauterine growth retardation (or restriction) (Dorland's Illustrated Medical Dictionary, 2007).
MHR:	Monica heart rate (see Excel spreadsheet).
Maternal:	Pertaining to the mother (Baillière's Midwives' Dictionary, 2008).

MOU: Midwife obstetric unit (Seedat, 2007:1).

MHRRA: Maternal heart rate recorded antenatally (see Excel spreadsheet).

NCCEMD: National Committee on Confidential Enquiries into Maternal Deaths (Department of Health, 2009:35).

PASS: Prenatal, Alcohol, SIDS and Stillbirth (Steering Committee, 2009:1)

PEP: Perinatal Education Programme (Woods, 2006:2).

PSVT: Paroxysmal supraventricular tachycardia (Taber's Cyclopedic Medical Dictionary, 2009).

SANC: South African Nursing Council (SANC, 2012).

SGA: Small for gestational age *(*Churchill Livingstone's Dictionary of Nursing, 2006) (see Excel spreadsheet).

Sinus tachycardia: Heart rate defined as at least 100 beats per minute under resting conditions (Klein & Galan, 2004: 446).

SV: Stroke volume *(*Dorland's Illustrated Medical Dictionary, 2007*).*

Sudden infant death syndrome (SIDS): The sudden unexpected death of an infant usually between the age of one month and a year of which no direct cause of death can be found after post-mortem. Traditionally this was called “cot death” and implies that a baby has been found dead for no obvious reason *(*Black’s Medical Dictionary, 2010*).*

Tachycardia: Is defined as a rise in the heart rate above the normal range at rest between 60 and 100 beats per minute. It can sometimes be accompanied by irregularities in rhythm (arrhythmia) (Black’s medical dictionary, 2010).

WHO: World Health Organisation (Mosby's Dictionary of Medicine, Nursing, & Health Professions, 2009*).*

CHAPTER 1: SCIENTIFIC FOUNDATION FOR THE STUDY

1.1 INTRODUCTION

1.1.1 Background and preliminary review of relevant literature

When pregnant women book at the antenatal clinic, their health information is recorded in a booklet, namely the maternity case record, or previously (before the 1st of October 2010), on a green antenatal card, which is then given to them after the first antenatal visit for their safekeeping. This booklet or antenatal card is presented with each subsequent antenatal visit and relevant information is then recorded by the health care provider. The purpose of the antenatal card/booklet is to summarise necessary information regarding the pregnancy in order for the health care provider to identify risk factors that could influence the course of the pregnancy and labour.

As the mentioned antenatal card is designed in a way that only necessary information can be recorded, the risk of leaving out some relevant information could occur. A possible void is that there is no provision made to record the maternal heart rate on the antenatal card except for under the heading “notes”. This space for entries, however, is limited. The void is thus that no provision has been made to record the maternal heart rate on the antenatal card.

The maternity case record however, is designed to enter all necessary obstetric information. The progress of a pregnancy and labour can be recorded from the first antenatal visit until the discharge after labour. There is no provision made for the routine monitoring of the maternal heart rate during the antenatal period unless the mother is admitted to hospital. By the recording of the maternal heart rate, possible problems may be identified early during pregnancy and gives one the opportunity to investigate the underlying cause and provide the adequate and necessary care.

In a situation where state hospitals and clinics, as well as private health care facilities, become very busy dealing with an overflow of patients, the potential for problems in health care such as time management, and/or the decline in the standard of record-keeping according to protocol, can arise. Although the lack of time could often result in doing only the necessary observations and diagnostic tests, this is not an appropriate professional excuse. Unfortunately it could happen that the health care provider will only provide the necessary care that is required from him/her, for example by

measuring the pregnant woman's blood pressure, but could be reluctant in monitoring the respiration or heart rate. Alternatively the health care provider might do these observations, but not record it on the antenatal card/booklet or in the patient notes.

Jefferies, Johnson and Griffiths (2010:113) maintain that clinical record-keeping plays an important role to all health care professionals including nurses, as it enables them to consider a far greater number of options when making a decision about the patient's condition. The authors mention that it is often argued that a nursing task performed, but not documented, is assumed in a legal context that this task has not been performed and the patient has suffered neglect arising from a lack of care. However, it can also happen that the patients forget or lose these cards, which unfortunately leads to the loss of valuable information, as there are often no duplicate documents available at the hospitals or clinics.

Gelson and Johnson (2010:617), remind us that the purpose of antenatal care is to ensure the continued wellbeing of the mother and fetus. The authors also highlight the importance of the prompt treatment of anaemia, urinary tract infection and arrhythmias. Intervention before major cardiac decompensation and the early diagnosis and management of conditions such as pre-eclampsia can prevent significant problems. Furthermore, the occurrence of cardiac symptoms, such as palpitations, chest pain and severe shortness of breath, should prompt early referral for investigation, promoting the timely diagnosis of an unsuspected cardiac disease in pregnant women. Therefore the researcher supported this authors' opinion that it is relevant to acknowledge the importance of the documentation of symptoms and findings during an antenatal consultation.

A Cochrane library search and Statistics SA search with the keywords "tachycardia"; "maternal tachycardia"; "nursing documentation of maternal tachycardia"; "prevalence of maternal tachycardia"; and "importance of nursing documentation of maternal tachycardia" revealed limited results for the time span 2006 to present, of which no review or study was related to the researcher's topic of interest. The majority of articles regarding tachycardia that were reviewed had been linked to a reaction to medication, resulting in tachycardia. However, no results were found regarding tachycardia being acted on or not, for the time span 2006 to present.

The Perinatal Education Programme (PEP) of the Western Cape (Woods, 2006, unit 1:6), highlights the importance of measuring blood pressure and pulse rate during the examination of the respiratory and cardiovascular system. However, it does not

provide guidance on the routine monitoring and assessment of the maternal heart rate during the course of pregnancy. The researcher assumed that tachycardia is often not measured and recorded at the antenatal clinics as there is either inadequate emphasis on routine monitoring of the maternal heart rate, and/or no provision is made for the monitoring and recording thereof.

According to Hanson (2010:9) maternal tachycardia could be a sign of a serious underlying condition, such as sepsis, and/or other potential intrapartum problems, such as anaemia (Woods, 2006, unit 13:5; Kotchetkov, Patel & Salehian, 2010:42). Lack of attention to maternal tachycardia during pregnancy could result in a potentially serious condition, such as maternal heart failure (Woods, 2006, unit 13:5). Therefore, the researcher was of the opinion that it is in the patient's best interest to monitor the maternal heart rate on a regular basis during routine antenatal care as any untreated or overlooked sign or symptom could potentially exacerbate a condition during pregnancy.

During pregnancy the pregnant woman's body undergoes significant physiological changes. These changes include changes to various systems of the body namely, the skin; reproductive organs; cardiovascular, haematological, renal, musculoskeletal, neurological, gastrointestinal (Sammaritano, 2010:729); endocrine, immune, respiratory, and alimentary systems; as well as the general metabolism (Sellers, 2004:141). Adapting to physiological changes can be both stressful and possibly life threatening in women with undiagnosed or undetected compromised cardiac function.

According to Klein and Galan (2004:446) the normal physiological changes include an increase in heart rate by 10 to 20 beats per minute, whereas sinus tachycardia is defined as a heart rate of at least 100 beats per minute. This study also mentions that the presence of the latter in an asymptomatic woman is not uncommon and can often be of no pathologic origin. Stein, Hagley, Cole, Domitrovich, Kleiger and Rottman (1999:980) studied the changes in 24-hour heart rate variability during normal pregnancy and found that the mean heart rate in normal, non-pregnant women is 76 beats per minute but increases to 87 beats per minute during pregnancy. Ferrero, Colombo and Ragni (2004:244) also mentioned that there is an increase in maternal cardiac arrhythmias during pregnancy. However, Tan (2010:113) states that cardiac arrhythmias are uncommon in pregnancy due to the low prevalence of heart disease in women in the reproductive age group. These findings are important, therefore the health care provider should not overlook either of them.

A study conducted in Sri Lanka by Haththotuwa, Attygalle, Jayatilleka, Karunaratna and Thorne (2009:197) investigated maternal deaths due to cardiac disease. The total number of maternal deaths that were reported was 145. There were 42 indirect deaths of which 25 were due to cardiac disease. This study considered interventions to reduce the maternal deaths. As part of their interventions, they suggested the early detection of risk factors of cardiac disease, such as a heart rate above 100 beats per minute (tachycardia); atrial fibrillation; cyanosis; clubbing; murmur; orthopnoea; and a dry cough. The authors emphasised the importance of observing the above mentioned signs and symptoms and referring patients for further investigation, if identified.

As revealed by the above preliminary literature review, it is clear that few studies have been done to investigate the heart rate in cardiovascular conditions related to maternal adverse outcomes. The researcher expressed interest to the prevalence of maternal tachycardia during late pregnancy and its association with anaemia and major cardiac disease and/or complications. This research focused on the prevalence of increased heart rate, also known as tachycardia, in the pregnant mother during late pregnancy (34 to 38 weeks gestation as tachycardia was noticed during the Monica AN24™ recordings done at this gestation) and understanding the complications thereof.

1.1.1.1 Ancillary study: Prevalence of maternal tachycardia during late pregnancy

This particular study is an ancillary research project from the main research project called the Safe Passage Study, which is an ongoing study on the role of prenatal alcohol exposure in sudden infant death syndrome and stillbirths (PASS). It is an in-depth study on the effects and role of prenatal alcohol exposure and its adverse outcomes on the pregnancy, the mother and the baby. This research project is community-linked and thus involved the direct members of the affected populations. This main research project is currently being conducted at two clinical centers namely, Cape Town, South Africa: Stellenbosch University; and the Northern Plains: Sanford Health/University of South Dakota. The principle investigators for the two centres are Hendrik Odendaal, M.D. (Cape Town), and Amy J. Elliott, Ph.D. and Larry Burd, Ph.D (South Dakota). Phase I of the main research project commenced in 2003 and phase II commenced August 2007 and is expected to be completed during 2014 (Ramirez, 2008:1). The researcher proposed that during the course of Phase II of the main study, some of the data that was collected by means of the Monica AN24™ fetal monitoring device, be used for this particular study to examine the prevalence of

maternal tachycardia during late pregnancy, namely the 34 to 38 week gestation period.

1.1.1.2 Monica AN24™ device

The Monica AN24™ is a small (115 x 55 x 19mm), wireless, electronic monitoring device that is connected to the gravid abdomen by five high quality electrocardiogram (ECG) electrodes. Monica AN24™ amplifies ECG signals that pass through the abdominal wall to determine the fetal and maternal heart rates. Preparations of the participant (positioning of pregnant woman and cleaning of electrode sites, as well as placement of electrodes) and equipment setup are done in accordance with the Monica AN24 Protocol (2009:1). Four electrodes are placed in a diamond shape on the gravid abdomen below the umbilicus of the participant (while relaxing in a comfortable position on her back, slightly tilted, 15˚, to one side) and the fifth electrode lateral to the right. Recordings of the fetal heart rate, maternal heart rate and uterine activity last at least 30 minutes (Monica AN24, 2009:1).

For the purpose of this study the researcher proposed to investigate the prevalence of maternal tachycardia during late pregnancy in greater detail and assessed its association with anaemia and major cardiac disease and/or complications.

1.2 PROBLEM STATEMENT AND RATIONALE

Resulting from the information in the previous paragraphs, the researcher was concerned that many of these conditions associated with tachycardia pass through the antenatal health care system without being noticed and investigated. As a professional nurse, the researcher observed a lack in the recording of the maternal heart rate at antenatal clinics.

Because limited global and apparently no local research has been done on the prevalence of maternal tachycardia during late pregnancy, a gap in the lack of knowledge thereof was identified. For this reason the researcher was of the opinion that this study would be of significant importance. Therefore, the researcher proposed to investigate the prevalence of maternal tachycardia during late pregnancy in greater detail and would assess its association with anaemia and major cardiac disease and/or complications.

1.2.1 Hypothesis

The researcher intended to address the following research hypotheses formulated for this study:

- Maternal tachycardia in late pregnancy is associated with underlying major cardiac disease.
- Maternal tachycardia in late pregnancy is associated with maternal anaemia.
- Maternal tachycardia in late pregnancy is associated with adverse maternal and perinatal outcomes.

1.2.2 Aim of this research

The aim of this study was to determine the prevalence of maternal tachycardia during late pregnancy and its association with anaemia, major cardiac disease and/or complications and adverse maternal and perinatal outcome.

1.2.3 Objectives

The objectives of this exploratory study were to:

- determine the prevalence of maternal tachycardia at 34 to 38 weeks gestation in a sub-population of patients enrolled in the Safe Passage Study;
- compare the empirical findings with a control group of normal maternal heart rates during late pregnancy;
- determine whether the presence of anaemia is common in maternal tachycardia;
- explore whether any underlying, pre-existing cardiac condition could be identified;
- determine the perinatal outcomes of pregnancy preceding, during, and after birth, in those patients presenting with maternal tachycardia; and
- determine maternal morbidity/mortality associated with anaemia and major cardiac disease and/or complications.

1.3 RESEARCH METHODOLOGY

1.3.1 Research approach and design

A quantitative research approach was selected to determine the prevalence of maternal tachycardia during late pregnancy and to determine the association between anaemia and cardiac lesions and also to compare it with a control group of normal maternal heart rates during late pregnancy. According to Burns and Grove (2009:22), quantitative research is a formal, objective, and systematic process in which numerical data are used to obtain information about the world.

Polit and Beck (2010:74) describes research design as the overall plan for obtaining answers to questions being studied and for handling various challenges pertaining to the value of the study evidence. This particular study was a case-control retrospective study within a prospective study because the researcher would analyse already collected data. An explorative and correlation research design was selected. Burns and Grove (2009:25) explain that correlation research involves the systematic investigation of relationships between or among two or more variables that have been identified in theories, observed in practice, or both. This type of design was thus best suited for the aim and objectives of the study.

1.3.2 Target population and sampling

A population refers to a term that sets boundaries on a study and includes individuals in the universe who possess specific characteristics (De Vos, Strydom, Fouche & Delport, 2009:193).

The population that were included from the main study was all the participants that were recruited during Phase II of the main study, between 20 July 2009 and 4 July 2011, to ensure that all the participants have delivered and have been discharged from hospital. According to the Safe Passage Study, Tygerberg Hospital statistics, 2097 participants were recruited during that time span. Of the 2097 participants, a total of 1431 Monica AN24™ routine recordings between 34 and 38 week's gestation were examined. These participants have completed delivery and have been discharged from hospital by the time the researcher completed data collection. These participants' recordings were examined to determine the overall prevalence of maternal tachycardia, thus forming the target population for this ancillary study (N=1431).

Arkava and Lane, as cited in De Vos *et al*. (2009:194), describe a sample as "elements of the population considered for actual inclusion in the study". The researcher opted for one type of sampling, namely:

- a non-probability, purposive sample (n=102) was used to select the participants presenting with maternal tachycardia to form the *case group*. This type of sample is "based entirely on the judgement of the researcher in that a sample is composed of elements which contain the most characteristic, representative or typical attributes of the population" (De Vos, 2001:198); and
- the *control group* was also selected by means of a non-probability, purposive sampling. After each case of maternal tachycardia was identified in the above

case group, the following participant - provided that maternal tachycardia was NOT present - was selected in a consecutive manner following the selection of each participant in the case group (n=102) to exclude possible environmental temperature changes that might have an influence on maternal heart rate as mentioned earlier.

In general it is stated that the larger the population, the smaller the percentage of that population's sample size needs to be. Based on Stoker's table (1985) (cited in De Vos, 2001:192), the researcher selected just over 14% of the population for the sample (thus 14.25%) for both the case group (n=102), and the control group (n=102) (N=1431 X 14.25% = 204 ÷ 2 = n=102).

1.3.3 Inclusion and exclusion criteria

The participants that were selected should have complied with the following criteria:

1.3.3.1 Inclusion criteria

To be included in this study, the participants:

- were recruited between 20 July 2009 and 4 July 2011;
- had a 34 to 38 weeks gestation Monica AN24™ recording;
- had at least 20 minutes of rest before recording was started; and
- had a recording done whilst lying on their back at 15˚ angle on her left or right side.

1.3.3.2 Exclusion criteria

Participants were excluded from this study if:

- they were recruited before 20 July 2009 and after 4 July 2011;
- any external factors were present that might have caused maternal tachycardia, e.g. latent labour; smoking in last 20 minutes before recording started; and
- they had exercised and ate in last 30 minutes before the recording was started.

1.3.4 Data collection instrument

In this study, a computerised Microsoft Excel spreadsheet was compiled by the researcher to collect the entire participant data set needed for the purpose of this study. This spreadsheet was designed to collect all the relevant information regarding the proposed study and the researcher herself entered the data. The items on the

spreadsheet were based on the research objectives set for this study, as well as reviewed literature.

The items on the spreadsheet were divided into different sections (columns) pertaining to each statement. Some of the statements required a “yes” or “no” answer. Other statements required a closed-ended answer to be selected from specified response options in a drop down menu on the spreadsheet. There were no statements that required open-ended answers.

A statistician from Stellenbosch University’s Statistical Department was consulted regarding the content and feasibility of the designed data collection instrument. The statistician also provided advice regarding the description of the study and comparison of the findings between the case group and control group.

1.3.5 Pilot study

A pilot study is defined by Burns and Grove (2007:38) as “a smaller version of a proposed study, and it is conducted to refine the methodology” of the study. The researcher did a pilot study by means of a pre-test of the data collection instrument and analysis of data before commencement of the main study. Leon, Davis, and Kraemer (2011:626) asserts that “the fundamental purpose of conducting a pilot study is to examine the feasibility of an approach that is intended to ultimately be used in a larger scale study”. This was done by the random selection of the participants’ information that was then used to complete, and test the data collection instrument by the researcher herself. The participants involved in the pilot study were selected from the same population as the main study. The information collected from the pilot study was not included in the main study or final data analysis and results.

According to Dawson and Trapp (2004:289), a large sample is not required to test an instrument; therefore a sample size of 1% (n=16) of the population sample (n=204) was included in the pilot study to determine any possible changes or modifications to the data collection instrument until the instrument efficiently measured the required objectives set for the study.

1.3.6 Reliability and validity

The *reliability* of a measuring instrument refers to the consistency of measures obtained in the use of a particular instrument and it indicates the extent of random error in the measurement method (Burns & Grove, 2009:377). Thus, the measured variables should measure the exact measurements if it is measured under the same

conditions each time. Along with the pilot study, the reliability of this study was also ensured by pre-testing the data collection instrument as it was tested under the exact same circumstances as the actual study.

De Vos *et al.* (2009:160) explain that the *validity* of an instrument measures the concept in question, and whether the concept is measured accurately. Thus validity refers to the extent to which an empirical measure accurately reflects the concept it is intended to measure. Face validity in this study was ensured by means of subjective judgements by experts in research methodology about the degree to which the instrument appeared to measure the relevant variables. Content validity in this study was assured by means of opinions of experts to validate the instrument (De Vos *et al.,* 2009:162). A statistician checked whether all the variables could be analysed statistically. Furthermore, the variables included in the data collection instrument were based on the objectives that were set for this study as well as a comprehensive literature review on the topic.

1.3.7 Data collection

Data collection was done by the researcher by means of a self-designed, computerised Microsoft Excel spreadsheet. The great advantage of the nature of this type of collection was that the researcher could collect the data in her own time. There was no need to make any physical contact with the participants, for the reason that all the data had already been collected by the Safe Passage Study. The researcher collected the data from the Monica AN24™ recordings' downloaded files as well as the copied hospital notes of each patient. The process of data collection continued until the sample reached the designated size, namely 102 participants for the case group and the control groups respectively.

Data collection took place from the 1st of August 2011 and was completed by the 20th of November 2011. The selected participants' data was only collected for one of the groups, namely either the case or control group according to the inclusion and exclusion criteria. Therefore, the same participants' data could not have been used more than once.

The data collection took place in Tygerberg Hospital at the Safe Passage Study secured office where the data is currently stored. The collected data for this study is stored on the researcher's private computer and a back-up copy is saved on a separate hard drive that is locked in a cupboard to be kept safe.

1.3.8 Data analysis and interpretation

At the time of data collection there were six Monica AN24™ devices available at Tygerberg PASS unit. After collection of the participants' data, the device was connected to the designated laptop computer with the DK 1.5b software to allow storage and analysis of the raw data. Subsequently, the files were sent from the laptop to a designated FTP directory on the local server from which they were downloaded on desktop computers for back-up and further analysis. This data was also copied on an external hard drive for analysis using the DK1.5b programme (Monica AN24, 2008:9). Additional information regarding the precise gestation at the time of data recording as well as delivery was obtained from maternal records at the research unit and manually added to the analysed data in Excel spreadsheet form.

MS Excel was used to capture the data and STATISTICA version 9 (StatSoft Inc., 2009) was used to analyse the data. Inferential statistical tests e.g. analysis of variance (ANOVA) was applied and the distributions of variables was presented with histograms and/or frequency tables. A statistician of Stellenbosch University was consulted for guidance regarding which inferential tests were appropriate. Univariate analysis was undertaken to establish whether association exists between cases and controls and the factors in the objectives such as maternal haemoglobin; anaemia; presence or absence of cardiac lesions or disease; presence or absence of infection; gestational age at delivery and birth weight. Where the factor was a continuous variable, a t-test was used. Contingency tables were used where factors in objectives were considered categorical. Multiple logistic regressions were used to determine the association of the factors with demographic variables.

1.3.9 Ethical considerations

According to the Department of Health (2004:3) the purpose of ethical principles for health research in South Africa is to identify good, desirable and acceptable conduct, to protect the welfare and rights of research participants, and to reflect the basic ethical values of beneficence, justice and respect for persons. The researcher protected the research participants by ensuring that the following criteria were met:

- A waiver of informed consent for this sub-study has been obtained based on the fact that all study procedures fall under the umbrella of the main study for which consent had already been obtained. The researcher explored already collected data, as well as the hospital records of the participants.
- There were no risks involved regarding the participation in this study. Confidentiality, privacy and anonymity were assured by separating the participants' consent form with their identity and their data files and not disclosing any information to others.

- Each data file for this sub-study was identified by a unique study code number known only to the researcher.
- The participants were only selected if they complied with the inclusion criteria of this study to assure their eligibility to take part in this sub-study.

1.4 STUDY OUTLAY

The outline of this research report is as follows:

Chapter 1: Scientific foundation of the study

A general overview of the research was given in this chapter. The overview included an introduction to the research topic, the rationale, hypothesis and problem statement, as well as the aim and objectives for the study. The methodology of the study was briefly explained and the ethical considerations were discussed in depth.

Chapter 2: Literature review

In this chapter, increased maternal heart rate, haemoglobin and anaemia and contributing factors to tachycardia were clarified. The concepts of the role and responsibilities of the midwife in antenatal care were also discussed. In addition, previous relevant research studies were reviewed and discussed.

Chapter 3: Research methodology

The research approach and design, selection of subjects for the sample, the data collection methods and process, as well as the data management were explained in detail in this chapter.

Chapter4: Data analysis and results

The analysis and interpretation of the findings were discussed in detail in this chapter.

Chapter 5: Conclusions and recommendations

This chapter contains the conclusions and recommendations of the study.

1.5 SUMMARY

A preliminary literature review was done on the prevalence of maternal tachycardia during late pregnancy and its association with anaemia and major cardiac disease and/or complications. The researcher experienced a lack of information and therefore identified a gap in research regarding this topic. There was no adequate information known about the prevalence of maternal tachycardia in the Western Cape and whether there was an association with anaemia and cardiac disease and/or complications. Recommendations were made regarding maternal heart rate monitoring during late pregnancy in relation to identifying possible underlying problems.

In this chapter, a general overview was given about the proposed research problem. The research was explained in the context of the research process as well as the steps that were followed to achieve the aim and objectives set for this study. Therefore it was clear that research was necessary to gain more information regarding maternal tachycardia in order to identify whether something could be done to ensure better maternal and perinatal care.

CHAPTER 2: LITERATURE REVIEW

2.1 INTRODUCTION

Optimal maternal health during pregnancy is essential for the good outcome of both mother and baby. In antenatal care, the focus should therefore be on the health and well-being of the fetus as well as that of the mother. Healthcare workers should be aware of signs or symptoms that are encountered during routine antenatal care that could indicate an underlying disorder.

A literature review was done based on the objectives set for this study as discussed in chapter 1. The literature study was done via an internet search on various databases, namely MD Consult; Google Scholar; Pubmed; Science Direct; Scopus; and Cinahl. The following code words and combinations of keywords were used as a search for relevant data, namely physiological changes during pregnancy; cardiovascular; maternal heart rate; haemoglobin changes; anaemia; prevalence of maternal tachycardia during late pregnancy; contributing factors to tachycardia; exercise and tachycardia; pain causing tachycardia; fever/pyrexia causing tachycardia; anxiety causing tachycardia; pathologic conditions causing tachycardia; hypovolaemia causing maternal tachycardia; tachyarrythmia causing maternal tachycardia; thyrotoxicosis causing maternal tachycardia; hypoxaemia causing maternal tachycardia; hypotension causing maternal tachycardia; substance misuse; smoking, alcohol abuse; substance abuse; and contributing causes of maternal tachycardia. Sources were mainly chosen according to their publication dates (2006-2011) and relevance to the topic. References dated before 2006 were only included where no recent publications were found.

Of particular interest for this study were the numerous changes in the maternal cardiovascular system. One of these, namely the increase in heart rate, deserves special attention, as an excessive increase in the heart rate, or tachycardia, could indicate underlying medical conditions, such as anaemia or heart failure (Woods, 2006:5). This particular study focused on the prevalence of maternal tachycardia as observed during prenatal evaluations.

2.2 PHYSIOLOGICAL CHANGES DURING PREGNANCY

2.2.1 General changes

During the course of pregnancy, almost every organ and system undergoes anatomical and functional changes to accommodate the developing fetus (Sela, Hen & Einav, 2011:69; Carlin & Alfirevic, 2008:801). As mentioned previously, these systems and organs include the skin; reproductive organs; cardiovascular, haematological, renal, musculoskeletal, neurological, gastrointestinal; respiratory; endocrine; immune; respiratory; and alimentary systems; as well as the general metabolism (Sammaritano, 2010:729; Quigley, 2007:879; Carlin & Alfirevic, 2008:804). In order to achieve optimal pregnancy outcomes, it is essential to understand the normal physiological changes that occur.

For the purpose of this study only the cardiovascular changes during pregnancy were discussed in detail.

2.2.2 Cardiovascular changes during pregnancy

The most profound physiological changes take place in the cardiovascular system. The physiological changes in pregnancy facilitate the adaptation of the cardiovascular system to the increased metabolic needs of the mother and the developing fetus. The majority of the cardiac changes arise in the first trimester and plateaus by mid-gestation, peaking again around the time of delivery (Carlin & Alfirevic, 2008:802).

The heart facilitates the provision of oxygen and nutrients and the removal of carbon dioxide and wastes to and from all the organs. Shah (2007:24) explains that the main determinants of oxygen delivery include the amount of oxygen carried by the blood and the delivery of the blood, called the cardiac output. The amount of oxygen carried by the blood is determined by the concentration of haemoglobin and the degree of oxygen saturation of haemoglobin.

2.2.2.1 Changes in cardiac output and blood pressure

During pregnancy, the cardiac output increases gradually by 30% to 50% (Tan, 2010:107; Maroo & Raymond, 2010:224) and peaks between 20 and 24 weeks of gestation (Gelson & Johnson, 2010:608), as a result of the increase in both stroke volume and heart rate (Gelson & Johnson, 2010:608; Swanton & Banerjee, 2008:526). This rise in cardiac output begins in early first trimester and reaches maximum values by mid-gestation (Tan, 2010:107). However, the systolic and diastolic blood pressure decreases in the first trimester by about 10 mm Hg, reaching

its lowest levels at about 20 weeks of gestation (Swanton & Banerjee, 2008:527). Systolic blood pressure decreases by 5 to 10 mm Hg and diastolic blood pressure decreases by 10 to 15 mm Hg during the mid-second trimester of during pregnancy. This increased blood pressure levels return to baseline levels by the late third trimester (Flack, Ferdinand, Nasser & Rossi, 2010:626).

Table 2.I indicates the haemodynamic changes that occur during the pregnancy, peripartum and postpartum period of women. This table shows the increase or decrease in the blood volume; systolic blood pressure; diastolic blood pressure; systemic vascular resistance; heart rate; stroke volume; and cardiac output. The arrows' pointing up or down in the particular table suggests whether there is an increase or decrease in the change during the particular period.

Table 2.1: Hemodynamic changes during pregnancy, peripartum and postpartum

Change	Pregnancy	Peripartum	Postpartum
Blood volume	↑	↑	↓
Systolic blood pressure	↓	↑	↑
Diastolic blood pressure	↓	↑	↑
Systemic vascular resistance	↓	↑	↑
Heart rate	↑	↑	↓
Stroke volume	↑	↑	↓
Cardiac output	↑	↑	↓

(Source: Silversides & Colman as cited in Oakley & Warnes, 2007:7)

2.2.2.2 Maternal heart rate during pregnancy

An increase in maternal heart rate, which occurs from 4 weeks of gestation, is one of the earliest cardiovascular changes that occur during pregnancy (Tan, 2010:107). During the course of pregnancy, the mean maternal heart rate usually increases by an average of 10 to 20 beats per minute (Oakley & Warnes, 2007:12; Camm, Lüsher & Serruys, 2006:608; Hill & Pickenpaugh, 2008a:392). Maroo and Raymond (2010:224) also reveal that heart rate only increases by 10 to 15 beats per minute.

The onset of this increase in maternal heart rate is within the first few weeks of pregnancy and peaks at about late second or early to the first half of the third trimester

(Oakley & Warnes, 2007:12; Camm *et al.,* 2006:608). Easterling and Stout (2007:914) explain that after 32 weeks of gestation, due to the fall in stroke volume, the maintenance of the cardiac output becomes more and more dependent on the heart rate, thus being a compensatory response.

A rise in heart rate leads to a decreased time for diastolic filling and can lead to reduced cardiac output and perfusion pressures (Carlin & Alfirevic, 2008:802). As indicated in figure 2.1, there is an increase in heart rate (HR), stroke volume (SV) and cardiac output (CO) during pregnancy up to the 38th week of gestation.

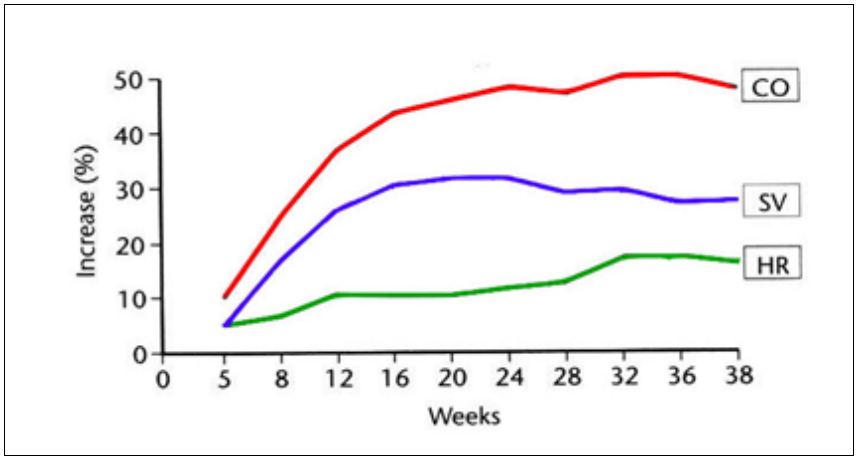

Figure 2.1: Heart rate, stroke volume and cardiac output in pregnancy

(Source: Presbitero, Boccuzzi, De Groot & Roos-Hesselink, 2006:608)

Figure 2.2 is an illustration of how an initial stimulus such as exercise or low blood pressure stimulates the sympathetic nervous system to increase the SV and HR and therefore, also cardiac output.

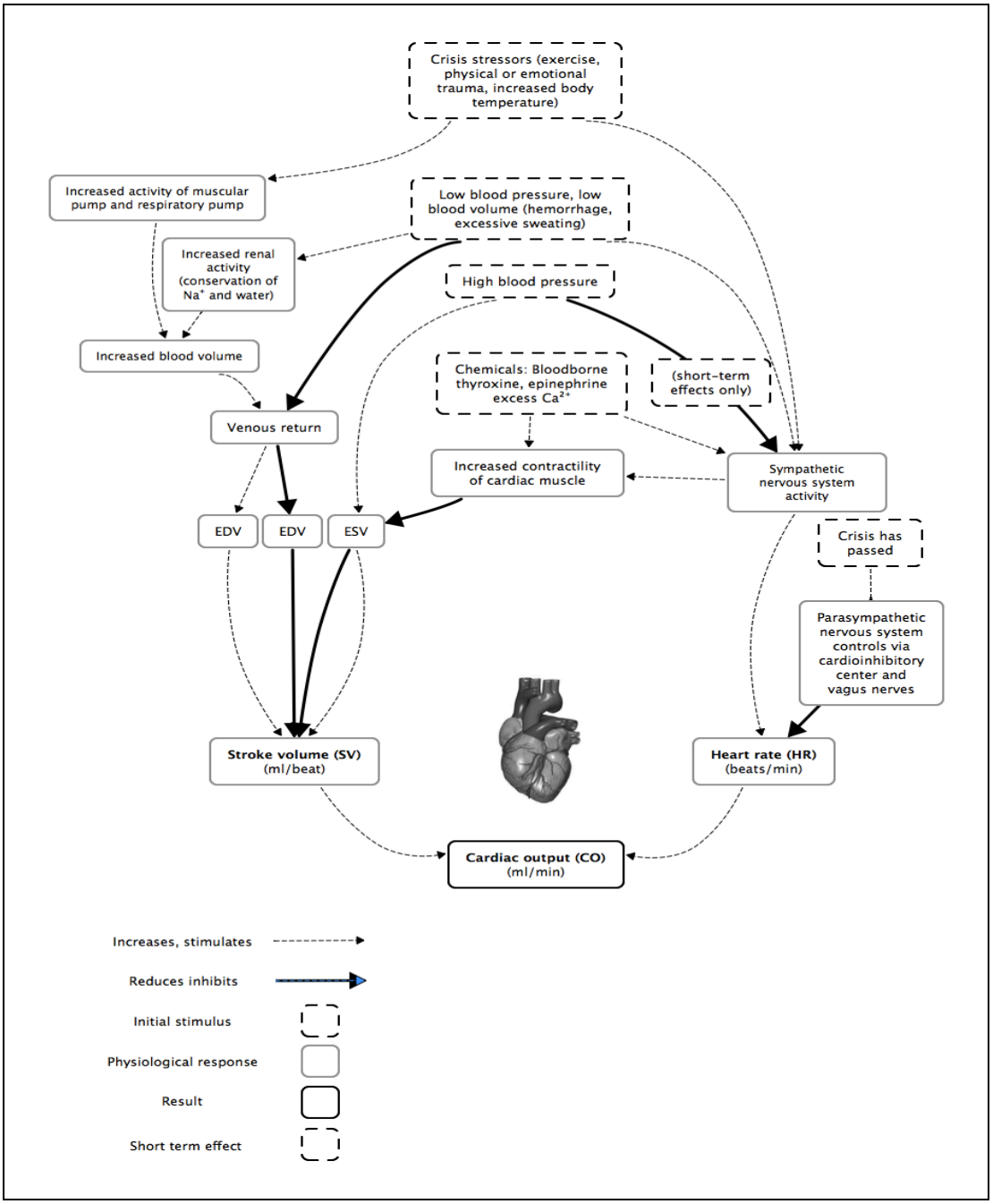

Figure 2.2: Factors involved in the regulation of cardiac output

(Source: Marieb, 2004:701)

2.2.3 Circulatory changes during pregnancy

Sela *et al.* (2011:61) summarise the physiological changes in the blood circulation during pregnancy as an increase in plasma volume and erythrocyte count; increased concentrations of most clotting factors; hormonal changes leading to cardiovascular effects, and effects secondary to uterine growth. The authors mention that due to the hormonal changes leading to cardiovascular effects, simulating exercise results in an

increased heart rate that could cause borderline physiologic tachycardia. For the purpose of this study only the haemoglobin changes and anaemia during pregnancy will be discussed briefly.

The normal range of haemoglobin values for non-pregnant women is between 12 and 16 g/dl and between 11 and 14g/dl for pregnant women (Blackburn, 2007:228). The lower end for the normal haemoglobin range in pregnancy is 11 to 12 g/dl (Carlin & Alfirevic, 2008:804). The World Health Organization (WHO) defines anaemia of pregnancy as a haemoglobin level of less than 11 g/dl, or a hematocrit less than 33%, at any point during pregnancy (WHO, 2001:33). Maroo and Raymond (2010:223) explain that this phenomenon occurs when the rise in blood volume of about 40% to 50% is greater than the increase in red blood cell mass and this contributes to the fall in the haemoglobin concentration during pregnancy. Thus, the maternal haemoglobin levels declines progressively from the first to the eighth month of gestation, then increases in the month before delivery (Lee & Okam, 2011:244). The plasma volume increases by a lesser amount in the last month of pregnancy, leading to a decrease in the intensity which thus causes the haemoglobin value to increase.

The common maternal signs and symptoms of anaemia include tachycardia, pallor, tachypnea, glossitis, fatigue, paresthesias, and headaches (Laubach & Bendell, 2008:2385); but according to Feisullin (2006:86) women are usually asymptomatic unless their haemoglobin value is less than between 6 to 7 g/dl. Laubach & Bendell, 2008:2385) claims that haemoglobin levels less than 6 g/dl in pregnant women can be associated with significant maternal and fetal complications because at these levels, tissue oxygenation decreases and may lead to a state of high-output congestive heart failure in the mother.

Comparing the views of the WHO (2001) and Lee and Okam (2011:242) it is clear that anaemia in pregnancy primarily affects women of a low socio-economic status and the risk of anaemia in pregnancy increases with the progression of the pregnancy. As noted by Laubach and Bendell (2008:235), previous studies have revealed a correlation between maternal anaemia and increased rates of both preterm (less than 37 weeks of gestation) and low birth weight deliveries. The author contends the importance to consider factors such as maternal nutrition and health; socio-economic conditions; and environmental influences that can independently affect pregnancy outcomes. The most common cause of anaemia during pregnancy is iron deficiency (Feisullin, 2006:87; Laubach & Bendell, 2008:2385; Woods, 2006:4). A study done to determine risk factors for birth outcomes and contributions of the populations to parts

and/or changes or findings, concluded that anaemia and maternal malaria continue to be significant causes of adverse pregnancy outcome in sub-Saharan Africa. This study also revealed that 63% of stillbirths were estimated as being attributable to maternal anaemia (Watson-Jones, Weiss, Changalucha, Todd, Gumodoka, Bulmer, Balira, Ross, Mugeye, Hayes & Mabey, 2007:9).

2.3 PREVALENCE OF MATERNAL TACHYCARDIA DURING PREGNANCY

A broad literature review was done on the title of the study and the researcher did not find any published articles with the same title or focus within the last five years. However, a number of studies have listed *tachycardia* as one of the normal cardiovascular signs that occur in pregnancy (Tan, 2010:108; Hill & Pickenpaugh, 2008a:394; Sammaritano, 2010:735). Carson, Powrie and Rosene-Montella (2002:40) found that 39% of healthy, asymptomatic patients in the third trimester of pregnancy had sinus tachycardia when in the seated position. This study found that 29% of the tachycardia cases were positioned on their left side. However, Zentner, Du Plessis, Brennecke, Wong, Grigg and Harrap (2009:603) emphasise a number of potential pathways or factors that can place stress on the cardiovascular system such as autonomic nervous system activation; insulin resistance; relative tachycardia; anaemia; and weight gain.

Reide and Yentis (2010:315) are of the opinion that all pregnant women are prone to tachycardia and arrhythmias, of which, in most cases, the symptoms are absent or mild, but in women with pre-existing cardiac disease the symptoms may be profound and severe. Although previous researchers have revealed that tachycardia during pregnancy is relatively normal, awareness thereof should not be ignored.

2.4 CONTRIBUTING FACTORS TO TACHYCARDIA

Tachycardia is a symptom of an underlying condition. Marschlinski, Fauci, Braunwald, Kasper, Hauser, Longo, Jameson and Loscalzo (2009:4) explain that tachycardia represents a physiological response to a variety of stresses and when a demand is placed on the heart, such normal or appropriate response to stress occurs as a result of either exercise; pain; anxiety; or pyrexia. It is also stated that pathologic conditions such as volume depletion, thyrotoxicosis, hypoxaemia, hypotension, congestive heart failure, drugs, and tachyarrhythmia can also cause tachycardia. Contributing causes of tachycardia of interest for this study, namely exercise; pain; pyrexia (fever); anxiety; and relevant pathologic conditions, are briefly described as follows.

2.4.1 Exercise

Exercise during pregnancy has proven to be beneficial for both the mother and the fetus. The physiological responses to exercise are increased oxygen consumption, redistribution of blood, altered venous pooling, as well as changes in the cardiac output and stroke volume, which thus causes the cardiac workload to increase (Blackburn, 2007:277). Exercise as a crisis stressor, stimulates the sympathetic nervous system activity that causes the heart rate to increase that ultimately elevates the cardiac output (Marieb, 2004:701). Zentner *et al*. (2009:600) suggest that the sympathetic hyper-reactivity in pregnancy is likely to contribute to an increase in the heart rate with activity and inadequate rest may cause confusing measurements.

A study was done in Canada to develop and validate a prediction equation for peak oxygen consumption by using a progression treadmill test and to refine the current target heart rate exercise guidelines for pregnancy (Mottola, Davenport, Brun, Inglis, Charlesworth & Sopper, 2006:1392). They found that the fit women in their cohort study had the aerobic capacity to have an average maximum heart rate of 180 (± 2 beats per minute) at 16 weeks gestation using a treadmill. The article addressed the peak oxygen consumption in pregnancy only and did not refer to tachycardia as such. The researchers support the current target heart rate zones of the Canadian Society for exercise guidelines (Canadian Society for Exercise Physiology, 2002), which entails that active women between 20 and 29 years of age can safely exercise with heart rates ranging between 135 to 150 beats per minute. Mottola *et al*. (2006:1391) add that this heart rate prescription should be coupled with a “talk test” which allows the pregnant women to carry out a conversation without being out of breath. A physical activity readiness medical examination (PARmed-X) for pregnancy is a guideline for health screening prior to participation in a prenatal fitness class or other exercise (Canadian society for exercise physiology, 2002).

Although pregnant women with a fast heart rate should maintain moderate exercise during pregnancy, adequate rest during periods of tachycardia is important to avoid stress (Quinlan, 2011).

2.4.2 Pain

A thorough literature search was done (MD Consult; Google Scholar) to explore “pain” as a contributing cause of tachycardia, but limited information was found. Pain is defined by Mosby’s Dictionary (2009) as “an unpleasant sensation caused by noxious stimulation of the sensory nerve endings; a subjective feeling and an individual

response to the cause". It is a cardinal symptom of inflammation and is valuable in the diagnosis of many disorders and conditions. Pain can be experienced as mild, moderate or severe, chronic or acute, burning, dull or sharp, precisely or poorly localized, or identified as a referred (reflective) pain (Mosby's Dictionary, 2009). It is possible that pain can cause tachycardia as the stimulation of the sympathetic nervous system causes a rise in the blood pressure and heart rate (Mendelson, 2005:398).

It is important to establish the cause of pain and treat it as soon as possible, because the etiology thereof could be dangerous to not only the pregnant woman, but the fetus as well. There are many causes of pain and therefore the health care provider should do the necessary examinations and investigations once a patient verbalises or presents with any degree of pain.

2.4.3 Pyrexia

A thorough literature search was also done (MD Consult; Google Scholar) regarding "fever" as a contributing cause of tachycardia in pregnancy but limited information was found. The abnormal rise in body temperature that frequently accompanies disease in general, is defined as fever or pyrexia (Black's Medical Dictionary, 2010). A common cause of fever in pregnancy is a maternal infection for example chorioamnionitis; urinary tract infection (UTI); upper respiratory tract infection (URTI); and septicemia (Apantaku & Mulik, 2007:12).

Snyder, Crawford and Jamieson (2007:401) avers that tachycardia in a febrile pregnant woman should prompt treatment for chorioamnionitis, even if she's already on antibiotics for group B streptococci. Clinical chorioamnonitis is defined as the presence of maternal fever greater than 38˚C. Maternal tachycardia (pulse rate of 100 beats per minute for 5 minutes) is one of the diagnostic signs for chorioamnionitis. The non-infective causes of fever during the intra-partum period are excessive pain; epidural analgesia; hot delivery room; and dehydration (Apantaku & Mulik, 2007:12). Therefore, the punctual monitoring of maternal observations should remain a high priority.

2.4.4 Anxiety

Anxiety is defined by Mosby's Dictionary (2009) as "the anticipation of impending danger and dread accompanied by restlessness, tension, tachycardia, and breathing difficulty not necessarily associated with an apparent stimulus". Anxiety is also part of

a crisis stressor as illustrated in figure 2.2, which stimulates the sympathetic nervous system activity and in effect elevates the heart rate.

A literature search was done via Science Direct and Google Scholar regarding the effects of maternal anxiety on the maternal heart rate and in particular maternal tachycardia in late pregnancy. To the researcher's knowledge, little is known and limited information was found in the literature about the effects or outcome of maternal anxiety on maternal heart rate. However, plenty of studies have been published that include the effects of maternal anxiety on the fetal heart rate (DiPietro, Costigan, Nelson, Gurewitsch & Laudenslager, 2008:11; DiPietro, 2010:27; Monk, Sloan, Myers, Ellman, Warner, Jeon, Tager & Fifer, 2004:283).

A review was done on studies that have used physiological stress reactivity in pregnant women and have concluded that physiological stress reactivity appears to be dampened during pregnancy (De Weerth & Buitelaar, 2005:295). Thus, consequences of stress such as changes in blood pressure, pulse rate and cortisol levels appear to be reduced in pregnancy. This particular study confirmed that physiological responses to laboratory challenges are present and thus enabled the study to make links between responsivity patterns, psychosocial variables, fetal behaviour, pregnancy outcome and offspring development. DiPietro *et al*. (2008:11) are of the opinion that maternal experiences create a cascade of physiological and neurochemical consequences that may alter the intra-uterine environment either directly or indirectly and thereby generate a fetal response. Researchers that studied maternal performance on a stressful mental arithmetic challenge observed that both maternal heart rate and fetal heart rate increase during maternal stress (McCubbin, 2009:174).

2.4.5 Pathologic conditions causing tachycardia

There are various pathologic conditions, abnormal anatomical or physiological conditions that cause tachycardia. The conditions discussed in the following section are chosen because of their relevance to maternal tachycardia, namely hypovolaemia, hypoxaemia, hypotension, thyrotoxicosis as well as the effects of medication or substance misuse, congestive heart failure, tachyarrhythmia and other underlying pre-existing cardiac conditions.

2.4.5.1 Hypovolaemia

Hypovolaemia, or volume depletion, is defined as an abnormally low volume of blood circulating in the body (Penguin English Dictionary, 2007). The developing signs of hemodynamic instability are hypotension and tachycardia (Katorza, Soriano,

Stockheim, Mashiach, Zolti, Seidman, Schiff & Goldenberg, 2007:501). According to Hill and Pickenpaugh, 2008b:422) pregnant women can lose 30% to 40% of blood volume (haemorrhage) before changes manifest in the heart rate and/or blood pressure. Maternal haemodynamic instability could present with symptoms such as hypotension and tachycardia, which are considered as threatening indicators. Cooper and McClure (2008:20) identified certain remediable factors such as poor recognition of concealed intra-abdominal bleeding as a problem. The latter further emphasises that the classical signs related to intra-abdominal haemorrhage such as tachycardia and tachypnea are still being ignored. Thereby the early recognition of hypovolaemia and correct interpretation of the vital signs play an important role in what the outcome of a patient's state of wellbeing may be. Antenatal women presenting with these symptoms usually require immediate intravenous fluid admission, fluid resuscitation, and possibly the administering of blood products (Sakornbut, Leeman & Fontaine, 2007:1199).

Hyperemesis gravidarum, or severe morning sickness in pregnancy, could be the cause of dehydration and volume depletion (Cheng, Montalto & Leff, 2009:82). Cuckson and Germain (2011:80) mention that nausea is experienced by 90% of pregnant women and 50% of pregnant women complain of vomiting. The authors list the signs of hyperemesis gravidarum as weight loss; ptyalism or excessive secretion of saliva; muscle wasting; tachycardia; and postural hypotension.

2.4.5.2 Hypoxaemia

Hypoxaemia is defined as a blood oxygen saturation of less than 90% (Majumdar, Eurich, Gamble, Senthilselvan & Marrie, 2011:325) and is explained as an abnormal deficiency in the concentration of oxygen in arterial blood (Mosby's Dictionary, 2009), thus better understood as decreased oxygen content in the blood. Due to the changes in the pulmonary physiology during pregnancy, pregnant women often complain of breathlessness and present with dyspnea (Morgan & Ernst, 2011:63). Pregnant women with a pre-existing pulmonary disease, such as asthma, suffer from chronic hypoxaemia (Aly, Nada, Ahmad, Mohamed, Massaro, Bathgate, Macri & Larson, 2011:1). According to Hegewald and Crapo (2011:1) (citing Archer & Marx, 1978) pregnant women are more susceptible to the development of hypoxaemia during periods of apnea, such as during acute endotracheal intubation. Maternal hypoxaemia adversely affects the fetus as it can quickly result in a decreased oxygen content supplied to the fetus. Therefore, chronic hypoxaemia could lead to intrauterine growth restriction and low birth weight (Hardy-Fairbanks & Baker, 2010:160). Although blood

gas tests and oxygen saturation are not routinely done during antenatal visits, it is essential that vital signs such as pulse rate, respiration, blood pressure and temperature are measured at these routine visits.

2.4.5.3 Hypotension

Hypotension is defined as “an abnormal condition in which the blood pressure is not adequate for normal perfusion and oxygenation of the tissues. An expanded intravascular space, hypovolaemia, or diminished cardiac output may be the cause” (Mosby, 2009). Maternal supine hypotension syndrome occurs when the pregnant woman lies in a supine position. It causes the inferior vena cava and abdominal aorta to compress, resulting in a decreased venous blood return to the heart (Hill & Pickenpaugh, 2008a:392). Effectively the hypotension reduces stroke volume that may result in a 25% to 30% decrease in cardiac output, which causes symptoms such as pallor; sweating; tachycardia; nausea; vomiting; and changes to the mental status (Hill & Pickenpaugh, 2008a:392).

Conditions such as cardiovascular and/or endocrine problems; dehydration; hypovolaemia or volume depletion; septicemia; anaphylaxis and poor nutrition could be possible causes of hypotension (Mayo Clinic, 2011). A study was done to investigate hypotension in pregnancy and its relation to pregnancy complications and birth outcomes. This study found no clinically important difference in the rate of preterm births and low birth weight newborns in pregnant women with or without hypotension (BÃ¡nhidy, Acs, PuhÃ & Czeizel, 2011:55).

2.4.5.4 Thyrotoxicosis

The term thyrotoxicosis refers to “the overactivity of the thyroid gland, leading to excessive secretion of thyroid hormones and resulting in increased basal metabolic rate” (Benders' Dictionary of Nutrition and Food Technology, 2006). During pregnancy, it is not only the size and activity of the thyroid gland that increases, but the thyroid-binding globulin and triiodothyronine levels that rise as well (Taber's Cyclopedic Medical Dictionary, 2009). Larsen, Davies, Schlumberger and Hay (2011:315) explains that the physiological changes during pregnancy entail an increase to the following: serum thyroxine-binding; plasma volume; iodine; thyroxin (T4) production; fetal thyroxin (T4) synthesis during second and third trimesters; as well as oxygen consumption by the fetoplacental unit, gravid uterus and the mother. Consequently, this causes an increase in the production of thyroxin which causes an

increase in the iodine requirements. The increased oxygen consumption causes an increased metabolic rate which results in a rise in the cardiac output.

Fitzpatrick and Russell (2010:182) aver that patients with hyperthyroidism can present with resting maternal tachycardia and if untreated, the maternal complications could lead to thyroid storm, including arrhythmia and congestive heart failure. The possible maternal complications may include thyrotoxicosis crisis; pre-eclampsia; pregnancy-induced hypertension; congestive heart failure; and postpartum thyroiditis (Luewan, Chakkabut & Tongsong, 2011:243).

2.4.5.5 Medication and substance misuse

A PubMed search was done on the following key terms: “smoking”; “alcohol abuse”; “substance abuse”; and “elevated heart rate”; “maternal tachycardia”; as well as “late pregnancy” with no time limit. Only one significant study done by Silva, Miller, Madden and Keegan (1987:144) was found that linked abnormal foetal heart rate pattern with severe intrapartum maternal ethanol intoxication. Furthermore a MD (Medical Doctor) Consult search (Melliere, 2012), using the same key words for the last 10 years, revealed few results but were insignificant for the purpose of this study.

Rayburn (2007:567) points out that maternal tachycardia is one of the withdrawal symptoms of alcohol overdose and withdrawal in pregnant women. It is important that the health care professional is aware if a patient abuses any drugs. Rayburn (2007:567) tabulated a number of medical, obstetric, and behaviour patterns in pregnant women that could be suggestive of substance use, such as anaemia; arrhythmias; restlessness; agitation; and various infectious diseases. Some of these behavioural patterns include tachycardia as a possible sign, for example anaemia and arrhythmias.

Habek (2007:866) claims that one of the effects of tobacco smoke on the placenta-umbilical circulation manifests as foetal and maternal tachycardia and contends that the complication rate in pregnancy rises proportionally to the number of cigarettes smoked per day.

No recent studies could be found on drug abuse as a contributing cause of tachycardia in pregnancy. However numerous earlier studies have revealed the adverse effects of cocaine abuse in pregnancy on the fetus, such as fetal tachycardia and hypertension (James & Coles, 1991:400). According to Smith and Deitch (1987:121) it is known that cocaine can cause maternal tachycardia. Medication such

as oxytocin and ephedrine may cause tachycardia and should be avoided if possible (Reide & Yentis, 2010:315). The central and peripheral effects of β-adrenergic drugs cause varying degrees of maternal tachycardia, peripheral vasodilatation, and hypotension (Greiss, 2008).

2.4.5.6 Congestive heart failure

Congestive heart failure is defined as an abnormal condition that reflects impaired cardiac pumping and the inability to maintain the metabolic needs of the body (Mosby's Dictionary, 2009). Its causes include myocardial infarction; ischemic heart disease; and cardiomyopathy. Failure of the ventricles to eject blood efficiently results in volume overload, ventricular dilatation, and elevated intracardiac pressure. Increased pressure in the left side of the heart causes pulmonary congestion. Increased pressure in the right side causes systemic venous congestion and peripheral oedema. Along with tachycardia, pregnant women with heart failure can present with symptoms such as worsening of the pulmonary or peripheral congestion, particularly dyspnoea; decreased oxygen saturation; excessive weight gain (due to peripheral oedema); and signs and symptoms of hypoperfusion such as hypotension and/or worsening of the mental status (Cruz, Briller & Hibbard, 2010:294). These signs can be difficult to recognise the disease in a pregnant woman, but suspicion should be raised with the presence of jugular venous distension; increased heart rate; and peripheral oedema (Cruz *et al*., 2010:294). Once any of these signs are recognised in a pregnant woman it should be either referred for further investigation, or be followed up by her next antenatal visit.

In pregnant patients with congestive heart failure, the already depressed cardiac reserve is further exacerbated by a sudden increase in plasma volume, increased total sodium concentration, anxiety with tachycardia and other factors such as bacteriuria with associated fever or any other febrile illness (Akintunde & Opadijo, 2011:139).

2.4.5.7 Tachyarrhythmia and other underlying pre-existing cardiac conditions

Taber's Cyclopedic Medical Dictionary (2009) defines tachyarrythmia as any cardiac rhythm disturbance in which the heart rate exceeds 100 beats per minute. Newstead-Angel and Gibson (2009) note that arrhythmia can present at any point in gestation, but are more likely to be exacerbated during periods of peak hemodynamic stress. Tan (2010:113) reveals that serious arrhythmia is uncommon in pregnancy. According to Maroo and Raymond (2010:227), premature atrial or ventricular complexes are not

associated with adverse maternal or fetal outcomes. However, Tan (2010:113) reveals that it may be the first sign of heart disease and should be excluded by careful physical examination and further investigation if necessary.

Tachycardia is evident in some arrhythmias such as paroxysmal supraventricular tachycardia (PSVT), atrioventricular nodal reentrant tachycardia, Wolf-Parkinson-White syndrome and ventricular tachycardia. Pulmonary diseases such as thrombo-embolic disease and rheumatic heart disease also present with tachycardia (Mosby's Dictionary, 2009). The most common arrhythmia in pregnant women is sustained PSVT. This condition is defined as any tachyarrhythmia with a heart rate above 120 beats per minute (Heatly, 2009:58; Robins & Lyons, 2004:140). Hormonal changes, alterations in autonomic tone, increased hemodynamic demand, and mild hypokalemia (or hypopotassaemia) increase the incidence of cardiac arrhythmias in pregnancy (Gelson & Johnson, 2010:607). Some adverse events of women who experienced arrythmia during the antepartum period include prematurity; respiratory distress syndrome; small for gestational age; and congenital heart disease (Silversides, 2006:1209). Hyperdynamic state, the altered hormonal milieu, and underlying heart disease are potential risk factors in pregnancy that can encourage the development of arrythmia. (Pérez-Silva & Merino, 2011).

The Confidential Enquiries into Maternal Deaths (NCCEMD) (Department of Health, 2009:35) reported that pre-existing cardiac disease was the most common cause of maternal deaths under the category pre-existing medical disorders during 2005 to 2007, which accounted for 6% of maternal deaths during this time span. This statistic was published in the Saving Mothers 2005-2007 report, which is the fourth report on confidential enquiries into maternal deaths in South Africa. Comparing the statistics of the third and fourth report, there is an increase in maternal morbidity and mortality due to pre-existing cardiovascular disease in South Africa (Department of Health, 2009:12). Although relatively infrequent, women with cardiac lesions are at exceptionally high risk of death during pregnancy if the disease is not detected and managed appropriately. This report further recommends the training of all health care professionals regarding the screening for cardiac disease (Department of Health, 2009:35).

According to Nelson-Piercy (2011:109) heart disease, as classified under the indirect maternal deaths, remains the most common cause of indirect maternal deaths in the United Kingdom for the years 2006 till 2008. The latter also avers that all the women who died, had identifiable risk factors such as obesity; older than 35 years; parity

larger than 3; smoking; diabetes; pre-existing hypertension; and a family history of heart disease.

2.4.5.8 Other contributing causes of tachycardia in late pregnancy

While it is simply not plausible to measure all the parameters and factors that may influence maternal heart rate in late pregnancy, it is possible to obtain useful information about the prevalence of maternal tachycardia in the current study. Other factors have also been suggested to have a possible influence on maternal heart rate during late pregnancy, such as maternal weight and/or intrauterine growth retardation (IUGR) influenced by cardiovascular function (Davenport, Steinback & Mottolla, 2009:341). These contributing factors are discussed briefly below.

2.4.5.9 Maternal weight

A study done by Carson *et al*. (2002:40) explored the effect of obesity and position on heart rate in pregnancy. This study's corresponding rates of sinus tachycardia when seated for obese and non-obese pregnant women were respectively 58% and 29%. The researchers revealed that resting tachycardia during routine antenatal visits may be more common than was previously recognised, as the majority of obese pregnant women were tachycardic when in the seated position. The only abnormality that was found on examination and laboratory testing was a high body mass index (BMI) (The Penguin Dictionary of Psychology, 2009).

2.4.5.10 Mode of delivery

A study done to measure maternal heart rate changes during labour concluded that a higher cardiovascular strain on physically less active women may represent an increased cardiovascular risk during labour (Söhnchen, Melzer, Martinez de Tejada, Jastrow-Meyer, Othenin-Girard, Irion, Boulvain & Kayser, 2011:5). Furthermore, these authors revealed that there were no significant differences between the heart rates of women who delivered spontaneously compared to women with instrument-assisted deliveries (forceps or vacuum). However, they did not investigate maternal heart rates during caesarian section. The same study also found no significant heart rate differences in women that delivered with or without epidural anaesthesia (Söhnchen *et al*., 2011:4).

2.4.5.11 Intrauterine growth restriction (IUGR)

A study done by Bamfo, Kametas, Turan, Khaw and Nicolaides (2006:787) explored the maternal cardiac function in 107 women with normal pregnancies and 20 with fetal

growth restriction (FGR) or IUGR. They found that there was reduced systolic function, characterised by lower cardiac output, stroke volume, heart rate, ejection time and septal and lateral long-axis shortening in the pregnancies complicated by fetal growth restriction. Another study to investigate maternal cardiovascular function in pregnancies complicated by IUGR found the maternal heart rate to be lower in the IUGR pregnancies (Prefumo, Perini, Paini, Bonzi, Lojacono, Agabiti-Rosei & Frusca, 2008:65). A following study comparing maternal cardiac function in women with IUGR to those small-for-gestational age (SGA) pregnancies (non-IUGR) found that maternal cardiac output (CO) was lower by 23% compared to the SGA group (Bamfo *et al.*, 2007:51). There was no association between maternal tachycardia and growth restriction.

From the above discussion regarding contributing factors of tachycardia in late pregnancy it seems clear that it is important to record the pregnant woman's heart rate in pregnancy. The Centre for Maternal and Child Enquiries (CMACE) mentions the following: "Carry out, record and act on basic observations for both low-risk and high-risk women"; and "recognise and act on symptoms suggestive of serious illness, including sepsis. These are two of the eight recommendations made for midwifery practice as set out in chapter 13 of Saving Mothers' lives 2006-2008 report in order to prevent maternal deaths in future (CMACE, 2006:149).

According to the aim and objectives set for this study the contributing causes of maternal tachycardia discussed in this chapter is believed to be appropriate. Any contributing cause that does not comply with the aim and objectives of this study was therefore not discussed.

2.5 THE ROLE OF THE MIDWIFE IN ANTENATAL CARE

A midwife is a person, who is educated and competent to practice independently, assumes accountability and responsibility for such practice and is registered in terms of the Nursing Act (SANC, 2004:47). The South African Nursing Council (SANC) currently controls the midwifery education and practice in South Africa (SANC, 2011). The role of the midwife consists of independent, interdependent and dependant roles. It is comprehensive in nature including activities such as screening, referrals, therapeutic activities, emergency treatment, education, counselling and provision of family planning services (Abrahams, Jewkes & Mvo, 2001:241).

The scope of practice of the midwife as explained by SANC (2004:49) is complete and extensive including the provision and management of care of all aspects that influence

the course of pregnancy, labour and puerperium. There are many other factors involving the scope of practice of a midwife such as the management and co-ordination continuity of care within the health care team (SANC, 2004:50). In order to practice, the registered midwife, and/or auxiliary nurse should be aware and understand his/her interdisciplinary role within which she/he may practice. The role of the midwife is bound to legislation and it is important that all nurses should adhere to legislation. Protocol is dependent on legislation and the availability of human and/or physical resources.

2.6 LEGISLATION

2.6.1 Nursing Act and regulations

The latest Nursing Act No. 33 of 2005, as well as the latest regulations to comply with this act, have been released. The researcher reviewed all the available regulations applicable to the topic related to this study. The South African Nursing Council (SANC) publishes regulations relating to the published scope of practice of persons who are registered and/or enrolled under the new Nursing Act, 2005 (SANC, 2011).

The following paragraphs discuss what this act denotes.

2.6.1.1 Nursing Act

Chapter one of the Nursing Act No. 33 of 2005 discuss information regarding the SANC. Chapter two of the Act entails education, training, research, registration and practice of nurses. In this chapter it is clearly stated that a professional nurse must be qualified and competent to independently practice comprehensive nursing in the prescribed manner and level. The professional nurse must be able to assume responsibility and accountability for such practice. A midwife must be qualified and competent to independently practice midwifery in the manner and to the prescribed level. The midwife must also be capable to assume responsibility and accountability for such practice.

The content of chapters three, four and five of this Act is not applicable and/or relevant to this particular study as it explains the powers of the Council with regard to professional conduct; offences by persons not registered; as well as general and supplementary provisions.

2.6.1.2 Regulations

All the regulations available on the SANC website (SANC, 2012) were reviewed and the researcher concluded that Government Notice No. 2598, the regulation relating to the scope of practice of persons who are registered or enrolled under the Nursing Act, 1978, have not yet been amended or repealed. In chapter two of this regulation it is stated that the registered nurse is responsible for the diagnosis, prescription, provision and execution of a nursing regimen so that patients' needs can be met, by referring to a registered person. Chapter three clearly states that the monitoring of the vital signs and the reaction of the mother and child to disease conditions; trauma; stress; anxiety; medication; and treatment of the mother and child during pregnancy, labour and puerperium is part of the registered midwife's duty. Chapter four of this regulation posits that the enrolled midwife is responsible for the control, promotion and maintenance of the blood pressure, temperature, pulse rate and fetal heart rate. Chapter five suggests that it is within the scope of practice of the enrolled nurse to monitor the vital signs and the observation of reactions to medication and treatment. Chapter six of the abovementioned regulation regarding scope of practice of enrolled nursing assistants, also includes the taking of the blood pressure, temperature, pulse and respiration of a patient.

From the above detail it is clear that it is within all nurses' scope of practice and their responsibility to measure the vital signs of the mother and baby throughout the pregnancy as well as during the intrapartum and postnatal period.

Government Notice No. 425 relates to the approval of, and the minimum requirements for the education and training of a nurse (general, psychiatric and community) and midwife leading to registration (SANC, 1985). Course subjects such as fundamental nursing science and general nursing science includes the observation and monitoring of vital signs. The programme objectives suggests that nurses are skilled in diagnosing of patients' health problems and the planning, implementing and evaluation of therapeutic action and nursing care for the health service consumers at any point along their health/illness continuum in all stages of life.

Government Notice No. 254 contains the detail of the programme for the diploma in midwifery leading to registration as a midwife (SANC, 1975). This regulation suggests that the curriculum of this course includes subjects to be taught in basic sciences; natural sciences; biological sciences; science of midwifery; preventive and promotive healthcare; and record-keeping. These subjects should be sufficient in providing the knowledge for nurses to provide quality continuous care.

Furthermore, Government Notice No. 212 (SANC, 1993) contains detail regarding the programme in clinical nursing science leading to registration of an additional qualification. Emphasis is placed on meaningful co-operation within the nursing and multi-disciplinary team in order to ensure proper referral to an appropriate registered person that forms part of the nurses' responsibility.

2.6.1.3 Protocol

According to Pattinson (2005:ii) basic antenatal care protocols are written guidelines to direct the nurses within South Africa's antenatal clinics regarding the referral criteria for certain conditions in pregnancy. The Basic Antenatal Care (BANC) protocol, as compiled by Pattinson (2005:i) is part of a quality improvement package that aims to bring together all the resources of the package and facilitate their use. This protocol is specific to a particular clinic (Department of Health, 2005). An example of this is the Parow Community Health Centre (CHC) protocol that dictates specific referral processes etcetera.

As discussed under the heading "Contributing factors to tachycardia" (see the first paragraph under heading 2.4), tachycardia is a symptom of an underlying condition brought about, for example, by exercise, pain, fever, anxiety and some pathologic conditions. The mentioned protocol is written to guide healthcare professionals in dealing with complex conditions and when to refer patients to the appropriate leve of care. There are written protocols for the proper management of the following conditions: hypertension; pre-eclampsia, including severe pre-eclampsia; malnutrition or obesity; moderate and severe anaemia; possible syphilis; unknown HIV status; possible HIV infection; positive HIV status; upper and lower urinary tract infection; vaginal discharge; very severe febrile disease; possible IUGR; possible multi-pregnancy or macrosomic fetus; post-term pregnancy; possible intra uterine death (IUD) (Easmin, Nahar, Jahan, Rahim & Nila, 2011); high maternal age; possible uterine and/or fetal infection; and abused pregnant woman (Department of Health, 2005). The mentioned protocols are necessary guidelines for referral criteria but in order to work efficiently, the researcher emphasises the importance of routine monitoring of the vital signs.

One of the objectives of the BANC program is to relieve the demands that the antenatal clinics currently experience. The BANC visits consist of five antenatal visits and are aimed at the low-risk pregnancies. The first booking visit is quite comprehensive, which includes the obstetric, general and medical history; a physical examination that includes assessing the heart rate and abnormal heart murmurs if

any; as well as some investigations such as HIV test; rapid syphilis test; and a haemoglobin test. At each visit the maternal blood pressure, weight, mid-upper arm circumference and a urine dipstick test is done routinely. Unless the pregnant woman verbalises that she feels unwell or if she appears to be unwell, there is no other routine monitoring of heart rate; respiration; or temperature performed at the follow-up visits. One can argue that sufficient care is provided, but the concern would be that unidentified signs and symptoms might not be detected if routine monitoring of the heart rate is not performed and recorded during these follow-up visits.

When the researcher asked about a protocol for the management and treatment of maternal tachycardia, the unit manager of the labour ward of Tygerberg Hospital revealed that there is no set protocol for the management and treatment of maternal tachycardia and patients are referred to this hospital according to the criteria of the BANC protocol (Lessing, 2011). When the same question was asked to a unit manager in at another hospital in the district, the response was also that there is no such set protocol for the management and treatment of maternal tachycardia, this person also referred to the BANC protocol (Anonym, 2011).

2.6.2 Guidelines

2.6.2.1 Perinatal Education Programme (PEP)

The PEP manual serves as a reference for the BANC programme. This manual does not recommend that the routine monitoring of the pulse rate during pregnancy should be done, however, haemoglobin estimation, urine test for protein and glucose is done at every visit as routine side room examination (Woods, 2006).

2.6.2.2 Guidelines for maternity care in South Africa

The guidelines for maternity care in South Africa as issued by the Department of Health, (2007) is a comprehensive document which serves to guide healthcare workers providing obstetric and anesthetic services in clinics, community health centres and district hospitals. According to these guidelines all women with a history or symptoms and signs of heart disease, must be referred to a specialist clinic with expertise in the management of cardiac conditions in pregnancy, usually at level two or level three hospitals. This guideline manual has a less than two page explanation and description about cardiac disease in pregnancy consisting of symptoms and signs, antenatal care, management of labour, management of the puerperium, and management of pulmonary oedema (Department of Health, 2007:120). The signs and symptoms of possible cardiac disease are shortness of breath with mild effort;

shortness of breath when lying flat; haemoptysis; palpitations; chest pain; dizziness; rapid (equal or above 100 beats per minute) or irregular heart rate; and heart murmurs. Although it also states that auscultation of the heart is routinely carried out where possible, it is in question whether the auscultation is actually done, or the heart rate is routinely done.

Although the previous version of the Guidelines for Maternity Care in South Africa (Department of Health, 2004:12) noted that health care workers at level one (clinics, community health centres, and day hospitals); level two and level three hospitals include midwives with PEP training, the new 2007 version (Department of Health, 2007) makes no mention of the PEP manual and training.

2.7 RESPONSIBILITIES OF MIDWIVES AT BANC CLINICS, MIDWIFE OBSTETRIC UNITS (MOU'S), AND HOSPITALS

The latest Nursing Act No 33 of 2005; recently released SANC regulations; written guidelines and protocols as discussed, all relating to the midwives' responsibilities.

As discussed previously, the BANC clinic personnel are guided by BANC protocol and the PEP manual and it is also trusted that they are trained accordingly. The healthcare professionals should use the BANC protocol as a guide to screen for possible complications and thus refer the patient if necessary.

BANC clinics and MOU's deal primarily with lower risk cases than what would occur at a hospital, but emergencies occur. All midwifes and registered professional nurses working at BANC clinics, MOU's and hospitals should be able to provide holistic maternal and neonatal care of good quality to the community.

The emphasis of care rendered by midwives at a MOU, should fall on low-risk patients, thus bringing midwifery care closer to the pregnant women (Mabale, 2003:23). This was the initial decision to move lower-risk maternity care closer to the people who need it, and to have this run by registered midwifes (Clow, 2011:1).

2.7.1 BANC clinics

In certain areas of the country, primary maternity services are provided as part of the National Health Plan (Abrahams *et al*., 2001:241). In these primary care settings pregnant patients are assessed at the BANC clinics on a follow-up basis and midwifes provide comprehensive services to women with normal uncomplicated pregnancies. Therefore, once a woman suspects pregnancy she starts attending the BANC clinic.

According to written protocol, the midwife is responsible to attend to all patients attending the clinic. The midwife should assess the normal growth of the pregnancy and screen for any problems arising during the course of pregnancy. Even though doctors usually visit the clinic once a week, women attending the services will only have a medical referral during pregnancy if they have a medical problem (Abrahams *et al*., 2001:241). In case of complications or problems, midwives assist and treat as far as possible within their scope of practice.

Depending on the size of the clinic, there are usually two to three midwives and one nurse on duty. BANC clinics are open during the day from 07h00 to 16h00.

2.7.2 Midwife obstetric units (MOU's)

Along with other responsibilities discussed in section 2.7.1, tasks of midwives range from coordinating patient care in the labour ward and postnatal section to the nursery. Other responsibilities the midwife is held responsible for is allocating staff for nursing activities.

A MOU is also a primary care setting where midwives work as independent practitioners providing services in antenatal, intrapartum, postpartum and newborn care (Abrahams *et al*., 2001:241). The primary difference between a MOU and antenatal clinic as opposed to a hospital is the fact that midwives at a MOU and antenatal clinic carry out their work without a medical practitioner in the unit. Pregnant patients with problems go to the unit, are assessed by a midwife and from there, a decision is made by the midwife whether the patient needs admission or referral. Should the midwife need advice regarding patient care, midwives are responsible for following the referral criteria, by usually telephonically contacting the doctor at a nearby hospital and asking for advice and then following doctor's instructions accordingly.

Midwives working at MOU's are responsible for monitoring the progression of labour, the fetal heart rate and delivery of normal vertex births. If any complication or emergency from admission should arise, these patients will and should, according to referral criteria, be referred to a nearby hospital. There are usually two to four midwives, one staff nurse and one to two nurses working per shift, depending on the size of the unit. These units work on a walk-in basis, thus patients cannot make any appointments, but booking at the nearest antenatal clinic is essential.

MOU's are usually open 24 hours a day, 7 days a week, including public holidays. Therefore these midwives are expected to work night as well as day shifts.

2.7.3 Hospitals

Hospitals fall under the primary, secondary or tertiary level where midwives work interdependently with medical doctors and obstetricians in high-risk pregnancy cases (Abrahams *et al*., 2001:241). Secondary and tertiary level hospitals have intensive care facilities (Gandhi, Welz & Ronsmans, 2004:181). A level three hospital has all the emergency care facilities where a level two hospital may have a neonatal intensive care unit. There is usually at least a prenatal (or antenatal), labour, and postnatal ward, as well as a nursery at each hospital. Adding to the responsibility of midwives working at hospitals includes providing pre- and post-operative care, for patients requiring caesarian sections. The hospitals are also better equipped to manage complicated deliveries, therefore the midwives are also responsible for assisting the doctor in doing a forceps or suction delivery, or doing it herself in case of an emergency when there are no doctors available to do it, provided that she has the necessary training and has been found competent in doing these complicated deliveries. The size of the wards in the hospitals directly influence the number of midwives and other nursing staff on duty per shift.

2.7.4 The role of the midwife regarding maternal tachycardia

In the search to determine whether there is a set protocol for the management and treatment of maternal tachycardia, a midwife working at the high risk clinic at an academic hospital, admitted openly: "I have never received a patient that has been referred for maternal tachycardia and I have also never referred a patient myself that primarily presented with maternal tachycardia" (Bosman, 2011).

Professor Theron, head of the department of obstetrics and gynaecology at Stellenbosch University concurs with Bosman's (2011) statement. According to Theron (2011) maternal tachycardia in the prenatal period will be categorised into two groups, the first, namely tachycardia presenting as a secondary condition to a primary condition such as, anaemia and pyrexia. The second, where there is an underlying cardiac problem, such as arrhythmic disorders or a valve lesion. These patients would usually know that they have a problem or they will present with a symptom such as dyspnoea (shortness of breath), which should then serve as a reason for their referral. However, if tachycardia is the only reason for referral, Theron (2011) notes that this

would be extremely rare and that there is no specific guideline or protocol for the management and treatment of primary maternal tachycardia in the Cape Metropole.

Murray and Huelsmann (2009:36) note that in sinus tachycardia, the nurse or midwife should perform an evaluation of the maternal temperature, pulse, blood pressure and respiratory rate before informing the physician. The nurse or midwife's assessment should help the physician decide the best treatment plan, which should be directed at alleviating or treating the cause of the sinus tachycardia.

2.7.5 Recordkeeping and reporting of abnormal observations

The previously used antenatal card does not allow special recording of the maternal heart rate. Also, the new maternity case record does not have specific space for the recording of the maternal heart rate routinely with each antenatal visit, only on admission to hospital. Research done to strengthen the health care system in a rural area in Gauteng Provence in South Africa revealed poor record-keeping; inadequate supervision; poor levels of clinical knowledge; and under-utilization of MOU's (Thomas, Jina, Tint & Fonn, 2007:38).

In the research to strengthen the health care system in the mentioned rural area in South Africa, the researchers addressed topics such as programme-specific training and improving recordkeeping. They divided interventions into programmatic interventions with specific but narrow focus, such as mother-to-child transmission of HIV and system-level interventions, such as the *health workers for change* (Thomas *et al*., 2007:46). The *health workers for change* is a WHO-tested intervention developed in South Africa to improve the health system's functioning and quality of interpersonal relations (between health workers as well as between health workers and patients) (Thomas *et al*., 2007:42).

2.8 LIMITATIONS

Although the PEP and BANC program are quite comprehensive in training, the researcher is of the opinion that there may be a shortfall in terms of the monitoring and the recording of the maternal heart rate. As previously discussed, the maternity case booklet now has got more space for the health care professional to write the findings of investigations.

2.9 SUMMARY

In this chapter an overview was given on the physiological changes during pregnancy and contributing factors and causes of tachycardia were discussed. The role of the midwife within the boundaries of legislation, protocol and guidelines were discussed briefly. The role and responsibilities of the midwife in antenatal clinics, midwife obstetric units and hospitals were also discussed.

This review of relevant literature, combined with the empirical findings of this study, will provide an understanding of the contributing factors and underlying medical conditions related to maternal tachycardia and may indicate changes to the protocol of antenatal care as used at present by health care facilities. By focusing on the prevalence of maternal tachycardia observed during prenatal visits at the Safe Passage Study, this study intends to bring attention to the impact a raised maternal heart rate has to the wellbeing of the mother and her unborn fetus.

The methodology to study the prevalence of maternal tachycardia during late pregnancy will be discussed in detail in Chapter 3.

CHAPTER 3: RESEARCH METHODOLOGY

3.1 INTRODUCTION

In chapter 2, relevant literature relating to the topic of research was reviewed. Concepts and variables that influenced the development of the data collection instrument were also introduced. This chapter entails the research methodology's different phases in depth to determine the prevalence of maternal tachycardia during late pregnancy. Mouton (2009:55) explains that research methodology consists of the systematic, methodological and accurate execution of the research design.

3.2 RESEARCH METHODOLOGY

3.2.1 Research approach and design

De Vos *et al*. (2009:75) summarises the purpose of a quantitative research approach as the testing of predictive and cause-effect hypotheses about social reality. A quantitative research approach was best suited for this study as the prevalence of maternal tachycardia during late pregnancy and its association with anaemia and cardiac lesions was determined. These findings were compared to that of a control group of pregnant women who had normal heart rates during late pregnancy.

This study had a case-control retrospective study design within a prospective study, because the analysis of already collected data was conducted. According to Mouton (2009:55), a research design is a plan or a blueprint of how one intends to conduct his/her research. Thus, a combination of explorative and correlational research design best suited this research study. A correlational design is defined as a study design for examining the relationships between or among two or more variables in a single group, which can occur at several levels (Burns & Grove, 2007:535). Elahi and Dehdashti (2011:1) describes that the most important purpose of an exploratory research design is to formulate hypotheses regarding potential problems and opportunities present in the decision situation. The abovementioned authors further explain that this type of research can be applied when, for example, the research objectives are identifying problems (Elahi & Dehdashti, 2011:1). The researcher chose a combination of these designs to maximise the possibility of obtaining valid answers to the research hypotheses. De Vos *et al*. (2009:106) explain the need for an exploratory study could arise in order to get acquainted with a situation so as to

formulate a problem or develop a hypothesis. Therefore, the researcher decided that a quantitative research approach best suited the nature of this retrospective study.

Mouton (2009:51) refers to the unit of analysis as the "what, object, phenomenon, entity process or event" that forms the main focus of which the researcher is interested in studying. In this study, pregnant women recruited for the Safe Passage Study that had a Monica AN24™ recording in late pregnancy at the Safe Passage Study, Tygerberg Hospital were the unit of analysis. Furthermore these recordings were analysed only to identify those pregnant women who presented with tachycardia to form the case group. In addition, these cases were compared with a control group of women with normal maternal heart rates.

3.2.2 Target population and sampling

The term target population is stated by Burns and Grove (2007:324) as "the entire set of persons (or elements) who (or that) meet the sampling criteria. In more detail, De Vos *et al*. (2009:194) describe target population as: "the totality of persons, events, organisation units, case records or other sampling units with which the research problem is concerned". The population targeted for data collection in this ancillary study included all the participants that were recruited for the main study phase II, as indicated by the Manual of procedures (2011:1), between 20 July 2009 and 4 July 2011. By the time the researcher completed the selection of participants, the majority of participants have had already delivered their babies and had been discharged from hospital. The statistics of the Safe Passage Study, Tygerberg Hospital revealed a total of 2097 participants that were recruited during that time span. To determine the overall prevalence rate of maternal tachycardia, as observed during the routine recordings between 34 and 38 weeks gestation, a total of 1431 Monica AN24™ recordings at this specific gestation were examined. The target population for this study is therefore 1431 participants (N=1431) from whom the participants who had tachycardia and the appropriate controls were selected. Of the total 2097 recruited participants recorded Monica AN24™ data, some data was lost and other participants had not yet had a Monica AN24™ recording at 34 to 38 weeks gestation but this would not have influenced the prevalence rate of tachycardia.

Seaberg, as cited in De Vos *et al*. (2009:194), describes a sample as a small set of the total set of objects, events or persons which together comprises the subjects of our study.

A non-probability, purposive sample (n=102) was used to select the participants presenting with maternal tachycardia to form the *case group*. A *control group* (n=102) was also selected by means of a non-probability, purposive sample as indicated in figure 3.1. Each *control group* participant was selected after each *case* of maternal tachycardia was identified in the *case group*. These participants were then selected in a consecutive manner following the selection of each participant in the *case group* (n=102). The reason for selecting the *control group* participants consecutively was to exclude possible environmental temperature changes that might have had an influence on heart rate as mentioned earlier in chapter one.

Purposive sampling is defined as the judgemental or selective sampling method that involves the conscious selection by the researcher of certain subjects or elements to be included in a study (Burns & Grove, 2007:344). Polit and Beck (2010:309) refers to non-probability sampling as the selection of elements by non-random methods, in other words the researcher would select a sample purposively or by judgement. The authors further explain that by using purposive sampling, the researcher purposively selects subjects who are judged to be typical of the population or typically knowledgeable about the issues under study (Polit & Beck, 2010:312).

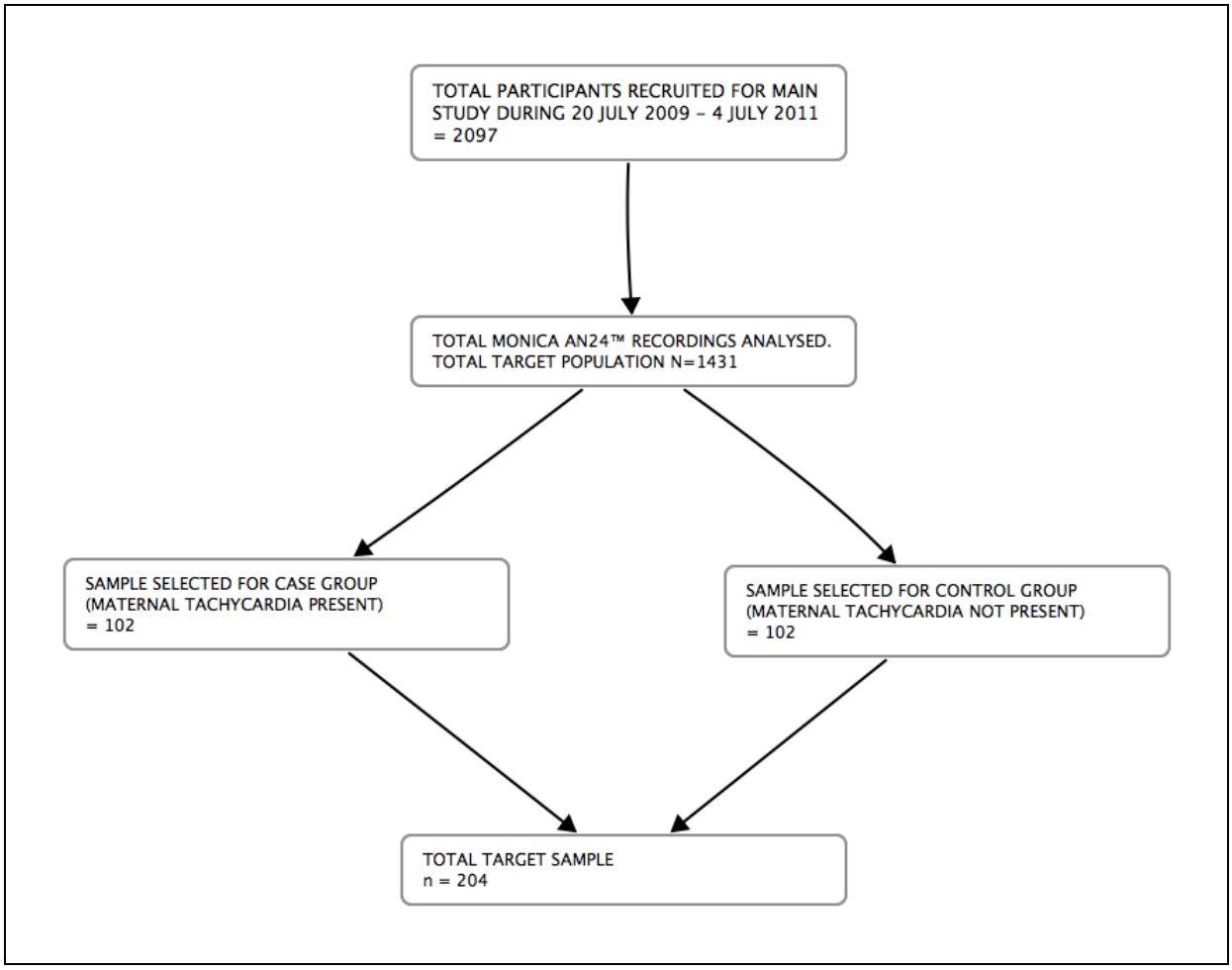

Figure 3.1: Target population and sampling outlay for this study

A statistician from Stellenbosch University's Centre for Statistical Consultation was consulted to determine the sample size for this study. Referring to section 1.2.2 in Chapter one, the sample size was calculated based on Stoker's table (1985) (cited in De Vos, 2001:192), the researcher drew just over 14% sample (thus 14.25%) for both the case group (n=102), and the control group (n=102) (N=1431 X 14.25% = 204 ÷ 2 = n=102). In addition, the accuracy of the proportions that are estimated from the sample increases marginally with a sample of more than 200 (Clopper & Pearson, 1934:404). Therefore it was decided that a total sample size of approximately 204 (n=204) was consequently efficient. The reason for this particularly outdated reference used was that the use of the binomial distribution has not changed since 1934 and is still used today to determine the sample size. For this reason, the researcher made the decision of the efficiency of the sample size of 204 (n=204).

3.2.3 Inclusion and exclusion criteria

Due to the fact that this is an ancillary study, the researcher only focused on the 34 to 38 weeks gestation period. There were certain inclusion and exclusion criteria for

participation in the main study, as explained in the Manual of Procedures, Version 3.1 (Sharepoint DM-Stat, 2011:76). The criteria listed below were modified from the criteria listed for the main study, except for the last two inclusion criteria, and exclusion criteria bullet number four, as these were only applicable to this study.

3.2.3.1 Inclusion criteria

To be included in this study, participants:

- had to be recruited between 20 July 2009 and 4 July 2011;
- had to have had a Monica AN24™ recording at 34 to 38 weeks gestation;
- had to have at least 20 minutes of rest before recording was started; and
- had to have a recording done whilst lying at a 15˚ angle left or right lateral tilt.

3.2.3.2 Exclusion criteria

Participants were excluded from this study if:

- they were recruited before 20 July 2009 and after 4 July 2011;
- any external factors were present that may have caused maternal tachycardia, for example latent labour; and smoking in last 20 minutes before the recording commenced; and
- they exercised or ate 30 minutes before the recording commenced.

The exclusion criteria in the last two listed bullets were decided upon for the reason to exclude any possible cause of maternal tachycardia. Therefore the Monica AN24™ recordings were carefully selected for inclusion in the study.

3.2.4 Data collection instrument

For this study a computerised Ms Excel spreadsheet was the data collection instrument. The researcher compiled this spreadsheet to collect the data needed for this sub-study. The researcher decided on a spreadsheet as the data collection instrument because data of the Monica AN24™ has already been done by the main study. According to the design of this study, other appropriate data needed for collection for this study could only be collected from hospital records of the participants that were selected for this sub-study. Therefore a data collection instrument to best collect all the appropriate information needed for this study was thus a computerized Ms Excel spreadsheet.

The items on this spreadsheet were based on all the objectives and reviewed literature. The spreadsheet was designed to divide the items into nine different

sections. Section one required the participants' unique study numbers and under which group they fall, for example, case or control. Section two required the participants' demographic data such as, maternal age, race, gravidity, parity, pregnancy losses, height and weight. The Monica AN24™ data of each participant was collected in section 3. Information regarding smoking was collected in the fourth section. Maternal heart rate recorded during the antenatal period was recorded in section five. Information regarding maternal haemoglobin values was collected in the sixth section. A summary of maternal and neonatal outcomes was collected in section seven and eight. In section nine a summary of the Apgar scores was collected.

The spreadsheet included statements that required a "yes" or "no" answer and some requiring close-ended answers that were selected from specified response options in a dropdown menu on the spreadsheet. No open-ended answers were included in this spreadsheet.

3.2.5 Pilot study

A pilot study was conducted by means of pre-testing the data collection instrument and analysing the data that was generated before commencement of the main study in order to "...bring possible deficiencies to the fore timeously" (De Vos *et al*., 2009:82). A pilot study is defined as a mini-study, small-scale version or trial run done in preparation for the main study (Polit & Beck, 2010:536). By pre-testing the data collection instrument, one typically tries out the instrument on a smaller number of participants having similar characteristics to those of the target group (De Vos *et al*., 2009:206).

The pilot study was done by means of selecting (sampling) the participants in the same manner as to which the main study were selected, namely purposively. This ensured that both case and control groups were included in the pilot study and not just in the main study. The participants involved in the pilot study were selected out of the same population as the main study.

As the pilot study usually forms a 5% to 10% sample of the selected participants, the researcher decided on an initial 5% (n=12) sample size for the pilot study. A total of 16 participants were finally included as no further changes needed to be made to the concept data collection instrument. The pilot study took place during the 1st and 31st of July 2011.

Changes to section five, maternal heart rate recorded during the antenatal period was made. The selection option on some dropdown boxes for example, “pre-existing cardiac conditions” were adjusted to better suit the main study. After collection of the 16 participants’ data for the pilot study and no more modifications were made to the concept data collection instrument, the data was sent to a statistician to determine if the data was free of any errors and could also be analysed statistically.

3.2.6 Reliability and validity

The reliability of a measurement procedure as referred to by De Vos *et al*. (2009:162) is the stability or consistency of the measurement. Reliability for this study was ensured by means of the conduction of a pilot study. The data collection instrument was pre-tested under the exact same conditions as the actual study. As mentioned under the section 3.2.5, 16 participants’ data were collected for the purpose of the pilot study. Changes were then made to improve the data collection instrument. Thus the instrument’s ability to “yield consistent numerical results each time it is applied” (De Vos *et al*., 2009:163) ensured that the instrument was reliable.

The validity of an instrument is measured on a continuum and is defined as the determination of how well the instrument reflects the abstract concept being examined (Burns & Grove, 2007:365). Face validity refers to the extent to which an instrument looks as though it is measuring what it professes or appears to measure (Polit & Beck, 2010:554). In this study, subjective judgements regarding the degree to which the instrument appeared to measure the relevant variables, was made by experts in research methodology.

De Vos *et al*. (2009:162) explains that construct validity is concerned with the meaning of the instrument and involves not only the validation of the instrument itself but also the theory underlying it. The authors point out that the meaning of the construct must be understood as well as the proposition the theory makes about the relationships between this and other constructs must be identified to be able to establish construct validity (De Vos *et al*., 2009:162).

Content-related validity is referred to by Burns and Grove (2007:535) as the extent to which the method of measurement includes all the major elements relevant to the construct being measured, thus what it is expected to measure. The content, feasibility and advice regarding the description of the study and comparison of the findings between the case group and control group was discussed with a statistician from Stellenbosch University’s Statistical Department. The opinions of experts

provided validation to the instrument and assured the content and construct validity for this study.

As the data collection instrument was designed, it was reshaped until there was surety that the data collected will measure what it is expected to measure. Also, the variables in the data collection instrument were based on the objectives that were set for this study. A statistician from Stellenbosch University's Centre for Statistical Consultation was consulted to check whether all the variables could be analysed statistically.

3.2.7 Data collection

Ethical approval was obtained from the Health Research Ethics Committee of Stellenbosch University's Division of Research Development and Support on the 3rd of June 2011. Data was collected by the researcher herself from the 1st of August 2011 and completed by the 20th of November 2011. The data collection instrument was a computerised Ms Excel spreadsheet, designed by the researcher herself. The data was collected in the researcher's own free time which was beneficial as she collected data as it suited her.

Unfortunately, to ensure that all the selected participants had delivered their babies and were discharged from hospital, data collection took longer than what was planned. Data collection took place at Tygerberg Hospital at the Safe Passage Study's secured office. The process continued until the sample reached the designated size, which was a total of 204 (n=204) participants that were selected for this study, respectively the case group (n=102) and the control group (n=102).

Each participant's data collected from the Monica AN24™ device were connected to a laptop, for downloading of the raw data. The integrated DK 1.2b software programme that was developed by the manufacturers examined the raw data. From this analysis, the researcher identified relevant candidates based on the selection criteria. Once these 204 candidates were identified, the DK 1.2b software data of each selected participant was revisited to collect more information.

Data was collected from the Monica AN24™ recordings as well as copied hospital records of each participant. Files of raw maternal heart rate data were obtained at the Safe Passage Study's secured office from the laptop where the Monica AN24™ recordings are downloaded after each recording. The files of raw data of each participant were copied to an external hard drive for later analyses. Copied hospital records of each participant were obtained from the same office. Section two of the

spreadsheet, demographic variables was collected from the copied hospital records. Section four to nine, data of maternal heart rate recording during antenatal visits, information regarding haemoglobin values, a summary of maternal and neonatal outcome and Apgar scores was obtained from the copied hospital records. This data was collected under section two of the spreadsheet. The researcher analysed the Monica AN24™ recordings and collected data such as maternal heart rate, fetal heart rate, the success of the recording and the duration and date of the recording.

3.2.8 Data analysis

Due to the fact that this is a quantitative study and that data was collected on an Microsoft Excel spreadsheet, the capturing of data was also done on Microsoft Excel. The DK 1.5b programme (Monica AN24, 2008:9) was used to analyse the raw data and extract the continuous maternal heart rate from the collected raw maternal ECG signals.

A statistician from Stellenbosch University's Centre for Statistical Consultation was consulted to perform the statistical analyses from the data collection instrument. The programme STATISTICA version 9 (StatSoft Inc., 2009) was used to analyse the data. The distribution of variables was presented with categorised histograms and frequency tables.

Chi-square statistics were used to analyse nominal data to determine significant differences between observed frequencies within data and frequencies that were expected (Burns & Grove, 2007:420). The relationships between continuous response variables and nominal input variables were analysed using appropriate analysis of variance (ANOVA). Univariate analysis is used to establish whether associations existed between cases and controls and the factors in the objectives such as maternal haemoglobin; anaemia; presence or absence of cardiac lesions or disease; presence or absence of infection; gestational age at delivery and birth weight was undertaken.

3.3 SUMMARY

The methodology used for this research project is discussed in detail in this chapter. The research approach and design; target population and sampling; inclusion and exclusion criteria; data collection instrument; pilot study; reliability and validity; data collection and a summary of the data analysis techniques were reflected on in this chapter.

In chapter four the analysis and interpretation of the results will be provided and discussed in detail.

CHAPTER 4: DATA ANALYSIS AND RESULTS

4.1 INTRODUCTION

The purpose of this study was to determine the prevalence of maternal tachycardia during late pregnancy and its association with anaemia, major cardiac disease and/or complications and adverse maternal and perinatal outcome. This study was quantitative in nature with a case-control retrospective study design. The researcher sampled 102 cases for the case group and 102 cases for the control group from a total of 1431 Monica AN24™ recordings that were examined. A computerised Microsoft Excel spreadsheet was used as the data collection instrument and the quantitative data was collected on nominal and continuous level.

The researcher looked at each individual variable and determined applicable outcomes which would yield the data relevant to the study. All data collected for this study were collected and entered on the computerised spreadsheet by the researcher herself. This approach required the researcher to read through every participant's copied hospital records to find the necessary data needed for collection.

As discussed in section 2.4 in chapter 1, all statements of the data collection instrument required closed-ended answers selected from specified response options in a drop down menu on the spreadsheet. There were no statements requiring open-ended answers. Data for some participants were lost, in which case a blank space was left on the spreadsheet where those entries had to be made. The results of each item were displayed in either histograms or frequency tables in this chapter and after each section a conclusive summary was made.

4.2 ANALYSIS OF THE QUANTITATIVE DATA

Mouton (2009:108) explains that analysis involves breaking the data into manageable themes, patterns, trends and relationships. The author further describes the aim of analysis is to understand the various constitutive elements of one's data through an inspection of the relationship between concepts, constructs or variables. Mouton (2009:108) furthermore states that analysis is also done "to see whether there are any patterns or trends that can be identified or isolated, or to establish themes in the data".

Quantitative data was generated and analyzed to provide information on the prevalence of maternal tachycardia during late pregnancy and its association with anaemia, major cardiac disease and/or complications and adverse maternal and

perinatal outcome. As mentioned previously, the raw quantitative data was captured and analysed using Microsoft Excel and STATISTICA version 9 software programmes (StatSoft., 2009). The percentages were rounded off to the first decimal to simplify the discussion in the text. Descriptive statistics were used to organise the data and describe the variables for this study (see par. 3.2.8).

The reader may find that some of the histograms do not total to 100%, which occur, according to the statistician who did the analysis of the data, due to rounding off of percentages. This is seen in many studies and is universally accepted.

4.2.1 Descriptive analysis of all the variables

The results for this study were presented in descriptive frequency tables and histograms, thereafter discussed sequentially under the following sections: Section A: Maternal demographic data; Section B: Monica AN24™ heart rate; Section C: Maternal heart rate recorded during antenatal period; Section D: Haemoglobin (Hb) value; Section E: Maternal outcome; Section F: Neonatal outcome; and Section G: Apgar score.

Table 4.1: Descriptive statistics of case group

Variable	Valid N	Mean	Median	Minimum	Maximum	Standard deviation
1. Maternal age (years)	102	22.9	22.0	16.0	43.0	5.7
3. Gravidity	102	1.8	1.0	1.0	6.0	1.0
4. Parity	102	0.7	0.0	0.0	5.0	0.9
6. Height (meter)	100	1.6	1.6	1.5	1.7	0.1
7. Weight (kilogram)	100	62.2	59.5	41.2	109	13.7
10. MHR success rate (%)	102	99.9	100.0	97.1	100.0	0.4
11. MHR duration of recording (minutes)	102	53.7	53.0	30.0	100.0	8.6
15. Number of ANC visits	93	5.9	6.0	2.0	13.0	1.8
16. Frequency of MHR recordings	93	11.7	8.0	1.0	69.0	10.7
17. MHRRA booking	101	0.0	0.0	0.0	0.0	0.0
18. MHRRA other ANC visits	101	0.1	0.0	0.0	4.0	0.6
19. MHRRA walk-in visits	94	0.6	0.0	0.0	17.0	2.1
20. MHRRA referrals	93	1.3	0.0	0.0	15.0	2.4

Table 4.1 continued…

Variable	Valid N	Mean	Median	Minimum	Maximum	Standard deviation
21. MHRRA labour	93	4.6	3.0	0.0	22.0	4.3
22. MHRRA post-delivery	93	5.1	3.0	0.0	52.0	7.4
23. Hb at booking (g/dL)	89	12.0	12.0	8.5	16.5	1.3
24. Hb at 28 – 38 weeks (g/dL)	85	10.7	10.5	7.0	14.0	1.3
25. Hb at delivery (g/dL)	46	10.5	10.4	7.1	15.5	1.7
26. Hb frequency	91	2.9	3.0	0.0	6.0	1.1
35. Birth weight (gram)	102	3226	3220	2250	4905	441
36. GA at delivery (weeks)	102	39.2	39.0	36.0	42.0	1.3
39. Apgar at 1 minute	102	8.8	9.0	5.0	10.0	0.8
40. Apgar at 5 minutes	102	9.8	10.0	6.0	10.0	0.6
41. Apgar at 10 minutes	52	9.9	10.0	8.0	10.0	0.3

*MHR - Monica AN24™ heart rate

*ANC - Antenatal clinic

*MHRRA - Maternal heart rate recorded antenatally

*Hb – Haemoglobin

*GA - Gestational age

Table 4.2: Descriptive statistics of control group

Variable	Valid N	Mean	Median	Minimum	Maximum	Standard deviation
1. Maternal age (years)	102	24.4	23.5	16.0	41.0	5.8
3. Gravidity	102	2.2	2.0	1.0	5.0	1.2
4. Parity	102	1.1	1.0	0.0	5.0	1.2
6. Height (meter)	100	1.6	1.6	1.4	1.8	0.1
7. Weight (kilogram)	101	62.3	60.0	40.0	101.5	14.8
10. MHR success rate (%)	102	99.9	100.0	97.9	100.0	0.3
11. MHR duration of recording (minutes)	102	55.2	55.5	20.0	93.0	9.0
15. Number of ANC visits	99	5.4	5.0	1.0	13.0	2.3
16. Frequency of MHR recordings	99	9.5	6.0	1.0	65.0	9.3
17. MHRRA booking	102	0.0	0.0	0.0	1.0	0.1
18. MHRRA other ANC visits	102	0.1	0.0	0.0	12.0	1.2

Table 4.2 continued…

Variable	Valid N	Mean	Median	Minimum	Maximum	Standard deviation
19. MHRRA walk-in visits	100	0.3	0.0	0.0	4.0	0.6
20. MHRRA referrals	99	0.8	0.0	0.0	22.0	2.4
21. MHRRA labour	99	3.6	2.0	0.0	23.0	5.1
22. MHRRA post-delivery	99	4.6	3.0	0.0	26.0	5.3
23. Hb at booking (g/dL)	93	12.0	11.9	8.1	15.3	1.3
24. Hb at 28 – 38 weeks (g/dL)	68	10.8	11.0	8.0	14.0	1.1
25. Hb at delivery (g/dL)	31	11.0	11.1	6.8	14.7	1.9
26. Hb frequency	95	2.5	3.0	0.0	5.0	1.1
35. Birth weight (gram)	102	3032	3050	1500	4400	604
36. GA at delivery (weeks)	102	38.9	39.0	34.0	42.0	1.7
39. Apgar at 1 minute	97	8.7	9.0	2.0	9.0	1.0
40. Apgar at 5 minutes	97	9.8	10.0	2.0	10.0	0.9
41. Apgar at 10 minutes	49	9.8	10.0	1.0	10.0	1.3

*MHR - Monica AN24™ heart rate

*ANC - Antenatal clinic

*MHRRA - Maternal heart rate recorded antenatally

*Hb - Haemoglobin

*GA - Gestational age

4.2.2 Section A: Maternal demographic data

In this section the information relating to the study sample in terms of the variables: maternal age; race; gravidity; parity; height; and weight were obtained. All the data of the various items was collected unless stated otherwise in the discussion of each.

4.2.2.1 Maternal age

Data of the maternal age included the case group (n=102) and the control group (n=102). Table 4.1 displays the basic descriptive statistics of the case group and table 4.2 that of the control group. In the case group the maternal ages ranged from 16 to 43 years with a mean of 22.9 years (Table 4.1). Forty point two percent (40.2%) of participants were between 15 and 20 years old (Figure 4.1). In the control group the ages ranged from 16 to 41 years with a mean of 24.4 years (Table 4.2) and 14.7% were between 16 and 18 and 20 to 22 years old, therefore a bimodal distribution (Figure 4.2).

A box plot of the maternal age of both groups is displayed in figure 4.3. The minimum age was 16 years and the maximum age was 43 years for the case group. The minimum age was 16 years and the maximum age was 41 years for the control group. The interquartile range which is the middle half of the data set for the case group is about 18 to 25 and for the control group 20 to 25 years. For both the case and the control groups the age distribution of most of the participants were on the low end of the scale, thus the distribution is skewed towards lower ages.

According to the analyses of variance (Table 4.3) the mean maternal ages did not differ significantly between the two groups. However the Mann-Whitney U Test, showed a significant difference ($p < 0.05$) between the two groups (Table 4.4).

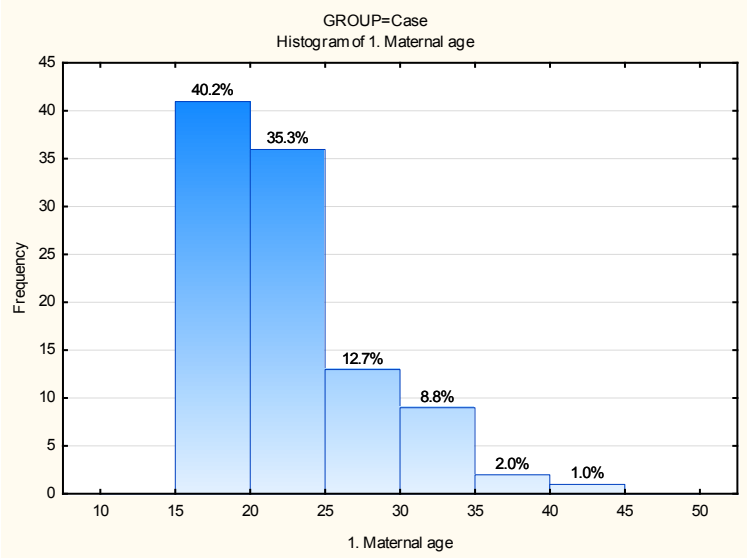

Figure 4.1: Maternal age of case group

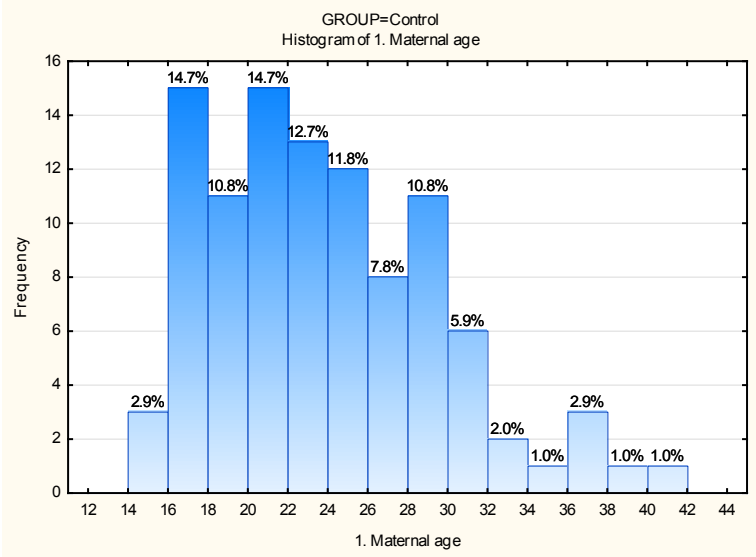

Figure 4.2: Maternal age of control group

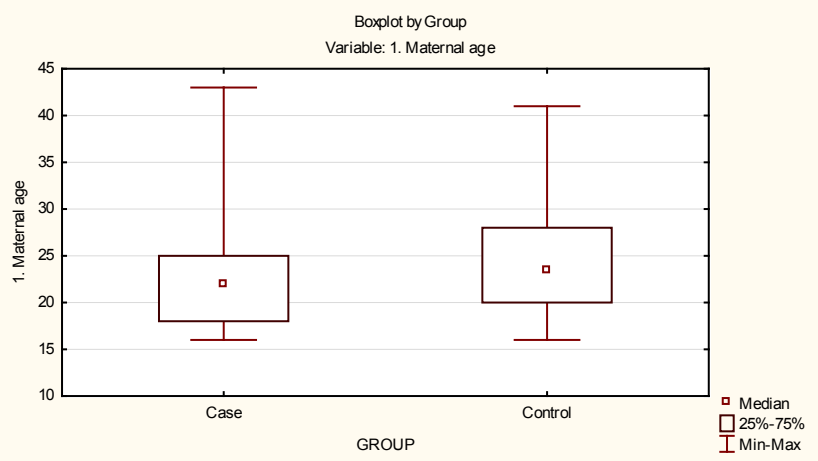

Figure 4.3: Box plot of maternal age of both groups

Table 4.3: Analysis of variance of variables

Variable	SS Effect	df Effect	MS Effect	SS Error	df Error	MS Error	F	p
1. Maternal age (years)	109	1	109	6634	202	32.8	3.3	0.07
3. Gravity	7	1	7	241	202	1.2	6.2	0.01
4. Parity	10	1	10	222	202	1.1	9.0	0.00
6. Height (meter)	0	1	0	1	198	0.0	0.0	0.94
7. Weight (kilogram)	1	1	1	40529	199	203.7	0.0	0.94
10. MHR success rate (%)	0	1	0	23	202	0.1	0.0	0.85
11. MHR duration of recording (minutes)	118	1	118	15726	202	77.9	1.5	0.22
15. Number of ANC visits	13	1	13	786	190	4.1	3.2	0.07
16. Frequency of MHR recordings	228	1	228	19083	190	100.4	2.3	0.13
17. MHRRA booking	0	1	0	1	201	0.0	1.0	0.32
18. MHRRA other ANC visits	0	1	0	184	201	0.9	0.0	0.93
19. MHRRA walk-in visits	6	1	6	443	192	2.3	2.4	0.12
20. MHRRA referrals	12	1	12	1127	190	5.9	2.0	0.16

Table 4.3 continued…

Variable	SS Effect	df Effect	MS Effect	SS Error	df Error	MS Error	F	p
21. MHRRA labour	47	1	47	4236	190	22.3	2.1	0.15
22. MHRRA post delivery	10	1	10	7745	190	40.8	0.2	0.63
23. Hb booking (g/dL)	0	1	0	307	180	1.7	0.2	0.74
24. Hb 28 – 38 weeks (g/dL)	0	1	0	219	151	1.5	0.3	0.57
25. Hb delivery (g/dL)	5	1	5	238	75	3.2	1.5	0.23
26. Hb frequency	7	1	7	224	184	1.2	6.0	0.02
35. Neonatal birth weight	1908200	1	1908200	5646654	202	279537	6.9	0.01
36. GA at delivery weeks	5	1	5	484	202	2.4	2.1	0.15
39. Apgar at 1 minute	0	1	0	152	197	0.8	0.3	0.56
40. Apgar 5 minute	0	1	0	107	197	0.5	0.0	0.85
41. Apgar 10 minutes	0	1	0	86	98	0.9	0.5	0.50

*MHR - Monica AN24™ heart rate

*ANC - Antenatal clinic

*MHRRA - Maternal heart rate recorded antenatal

*Hb - Haemoglobin

*GA - Gestational age

Table 4.4: Mann-Whitney U Test

Variable	Rank Sum Case	Rank Sum Control	U	Z	p-value	Z adjusted	p-value	Valid N Case	Valid N Control	2*1 sided exact p
1. Maternal age (years)	9578.0	11332.0	4325.0	-2.08	0.04	-2.08	0.04	102	102	
3. Gravidity	9445.5	11464.5	4192.5	-2.39	0.02	-2.54	0.01	102	102	
4. Parity	9345.5	11564.5	4092.5	-2.63	0.01	-2.82	0.00	102	102	
6. Height (meter)	10071.0	10029.0	4979.0	0.05	1.00	0.05	0.96	100	100	
7. Weight (kilogram)	10142.0	10159.0	5008.0	0.10	0.92	0.10	0.92	100	101	
10. MHR success rate (%)	10803.5	10106.5	4853.5	0.83	0.41	1.01	0.31	102	102	
11. MHR duration recording (minutes)	9189.0	11721.0	3936.0	-3.00	0.00	-3.01	0.00	102	102	
15. Number of ANC visits	9659.5	8868.5	3918.5	1.78	0.08	1.81	0.07	93	99	
16. Frequency of MHR recordings	9726.5	8801.5	3851.5	1.95	0.05	1.96	0.05	93	99	
17. MHRRA booking	10251.5	10454.5	5100.5	-0.12	0.90	-0.99	0.32	101	102	
18. MHRRA other ANC visits	10504.0	10202.0	4949.0	0.48	0.63	1.64	0.10	101	102	
19. MHRRA walk-in visits	9438.0	9477.0	4427.0	0.70	0.49	0.90	0.37	94	100	
20. MHRRA referrals	9636.5	8891.5	3941.5	1.72	0.09	1.98	0.05	93	99	
21. MHRRA labour	10154.0	8374.0	3424.0	3.06	0.00	3.10	0.00	93	99	
22. MHRRA post-delivery	8981.5	9546.5	4596.5	0.02	0.99	0.02	0.99	93	99	
23. Hb booking (g/dL)	8053.5	8599.5	4048.5	-0.25	0.80	-0.25	0.80	89	93	
24. Hb 28-38 weeks (g/dL)	6397.5	5383.5	2742.5	-0.54	0.59	-0.55	0.59	85	68	
25. Hb delivery (g/dL)	1654.5	1348.5	573.5	-1.44	0.15	-1.44	0.15	46	31	0.15
26. Hb frequency	9235.5	8155.5	3595.5	1.98	0.05	2.07	0.04	91	95	
35. Birth weight	11452	9458.5	4205.5	2.36	0.02	2.36	0.02	102	102	
36. GA at delivery weeks	10912.5	9997.5	4744.5	1.08	0.28	1.11	0.27	102	102	
39. Apgar 1 min	10357.0	9543.0	4790.0	0.39	0.70	0.63	0.53	102	97	
40. Apgar 5 min	9979.0	9921.0	4726.0	-0.54	0.59	-0.94	0.35	102	97	
41. Apgar 10 min	2554.0	2496.0	1228.0	-0.14	0.88	-0.38	0.70	51	49	0.89

4.2.2.2 Race

The discussion of the maternal race included both groups (n=204), namely the control group (n=102) as well as the case group (n=102). All the participants were coloured people (n=204 or 100%).

4.2.2.3 Gravidity

The discussion of the maternal gravidity included both groups (n=204), namely the control group (n=102) and the case group (n=102), as well as the two groups individually. The gravidity for both groups ranged from gravida one to gravida six. The mean gravidity for the case group was 1.8 (Table 4.1). The mean gravidity for the control group was 2.2 (Table 4.2). The median gravidity for the case and control groups was 1 and 2 respectively (Table 4.1 and 4.2). Therefore, the majority of participants in the case group were gravida one and the majority of participants in the control group were gravida two. The majority of all the participants were gravida one (n=90 or 44.1%) (Table 4.5). From figure 4.4, it is clear that the majority of participants in the case group was gravida one (n=52 or 51.0%), which is 14% more, comparing to the majority of the control group, also gravida one (n=38 or 37.0%) (see figure 4.5). According to table 4.3, the analyses of variance and also the Mann-Whitney U Test (Table 4.4) the gravidity showed a significant difference ($p < 0.05$) between the two groups.

Table 4.5: Maternal gravidity of both groups

Gravidity	Frequency (*f*)	Percentage (%)
1	90	44.1
2	58	28.4
3	34	16.7
4	16	7.8
5	5	2.5
6	1	0.5
Total	**n=204**	**100**

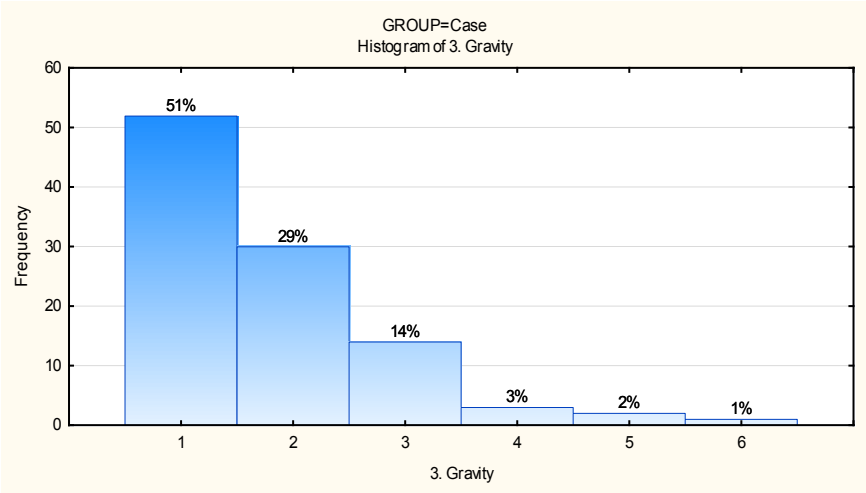

Figure 4.4: Maternal gravidity of case group

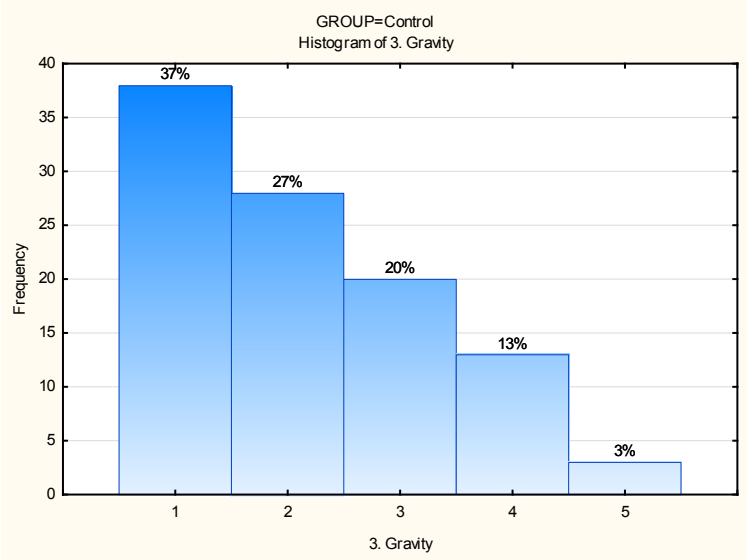

Figure 4.5: Maternal gravidity of control group

4.2.2.4 Parity

The discussion of the maternal parity included each individual group, namely the control group (n=102) and the case group (n=102). The parity for each group ranged from parity zero to parity five. The mean parity for the case group was 0.7 (Table 4.1) and the mean parity for the control group was 1.1 (Table 4.2). As indicated in figure 4.6 the majority of the participants in the case group were nulliparous (n=56 or 55.0%). The majority of the participants in the control group as indicated in figure 4.7 were also nulliparous (n=40 or 39.0%) however, fewer than the case group. According to table 4.3 the analyses of variance and the Mann-Whitney U Test (Table 4.4) parity showed a significant difference ($p < 0.05$) between the two groups.

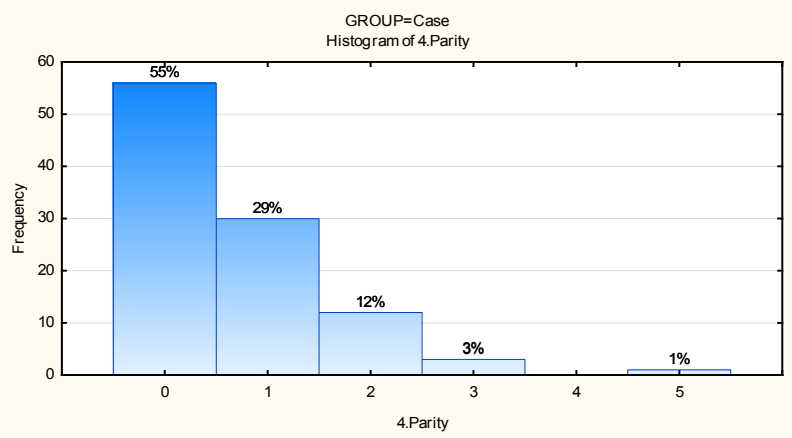

Figure 4.6: Maternal parity of case group

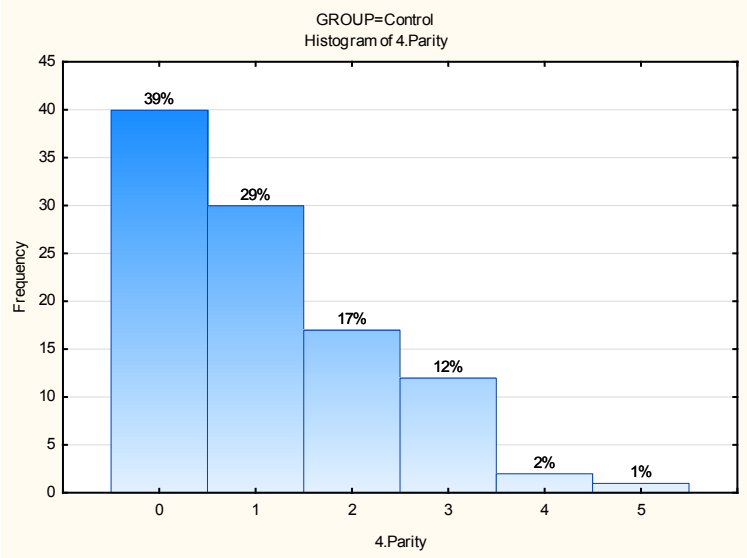

Figure 4.7: Maternal parity of control group

4.2.2.5 Pregnancy losses

The discussion of miscarriage included both groups (n=204), namely the control group (n=102) as well as the case group (n=102). As indicated in table 4.6 the cumulative count of the category of pregnancy losses was 18, of which the majority have had one previous miscarriage (n=10 or 55.5%). The description of each acronym is next to the acronym in the Table 4.6.

Table 4.6: Pregnancy losses of both groups

Category	Frequency (*f*)	Percentage (%)
MISC1 (first miscarriage)	10	55.5
ID (infant death)	2	11.1
AB1 (first abortion)	3	16.6
AB2 (second abortion)	1	5.6
IUD (intra uterine death)	1	5.6
MISC2 (second miscarriage)	1	5.6
Total	**n=18**	**100**

4.2.2.6 Height

The data of four (n=4) of the participants were not available, two (n=2) from the control group and two (n=2) from the case group, as it was not entered in the copied records. The discussion of the maternal height included the individual groups namely the control group (n=100) and case group (n=100). Although the height of the participants was entered individually in Excel, the analysis thereof was grouped in height ranges. As indicated in figure 4.8 the most frequent height of the participants in the case group was in the range of 1.58 to 1.6 meters (n=13 or 13.0%). As indicated in figure 4.9, the most frequent height of the participants in the control group was in the range of 1.55 to 1.60 meters (n=32 or 32.0%). According to the analyses of variance (Table 4.3) and the Mann-Whitney U Test (Table 4.4), the height showed no significant difference ($p < 0.05$) between the two groups.

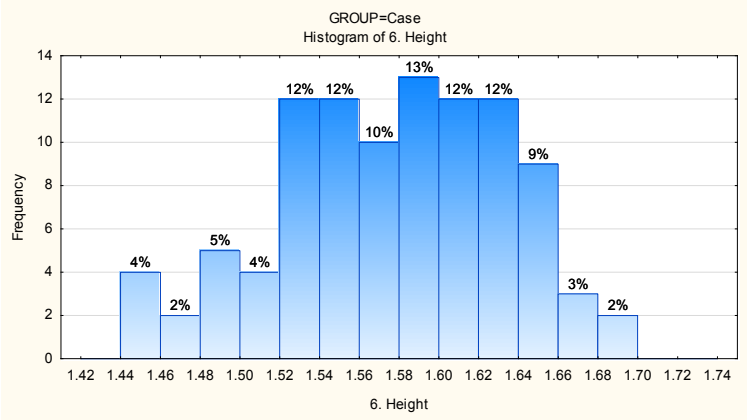

Figure 4.8: Maternal height of case group

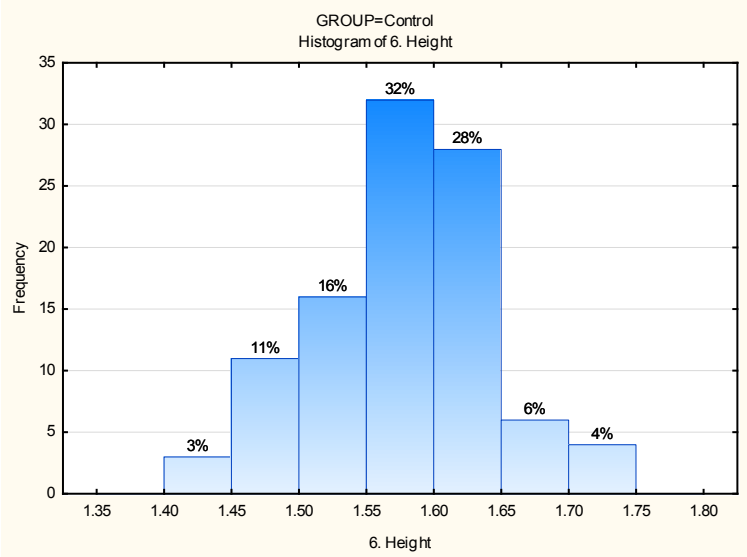

Figure 4.9: Maternal height of control group

4.2.2.7 Weight

The data of three (n=3) of the participants were not available, as it was not entered in the copied records. Although the weight of the participants was entered individually in Excel, the analyses thereof were grouped in weight ranges. As indicated in figure 4.10, the most frequent weight of the participants in the case group was 51 to 60 kilograms (34.0%). As indicated in figure 4.11 the most frequent weight of the participants in the control group was 50 to 54 kilograms (16.0%). According the analyses of variance (Table 4.3) and the Mann-Whitney U Test (table 4.4), the weight showed no significant difference ($p < 0.05$) between the two groups.

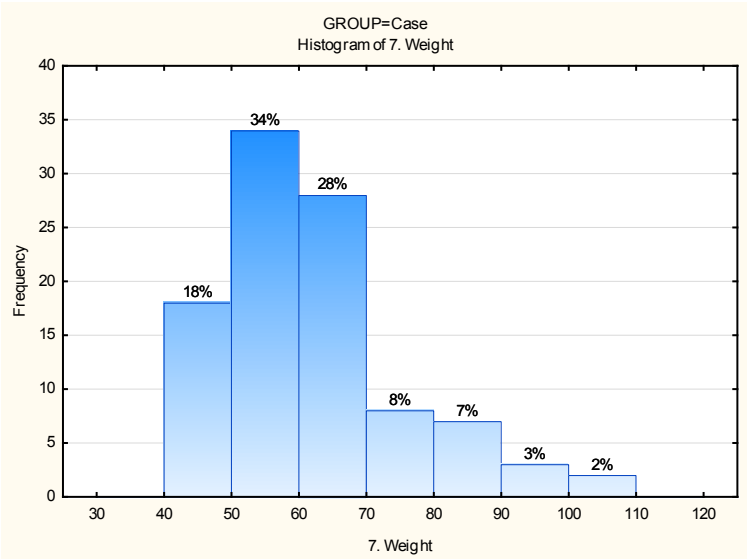

Figure 4.10: Maternal weight of case group

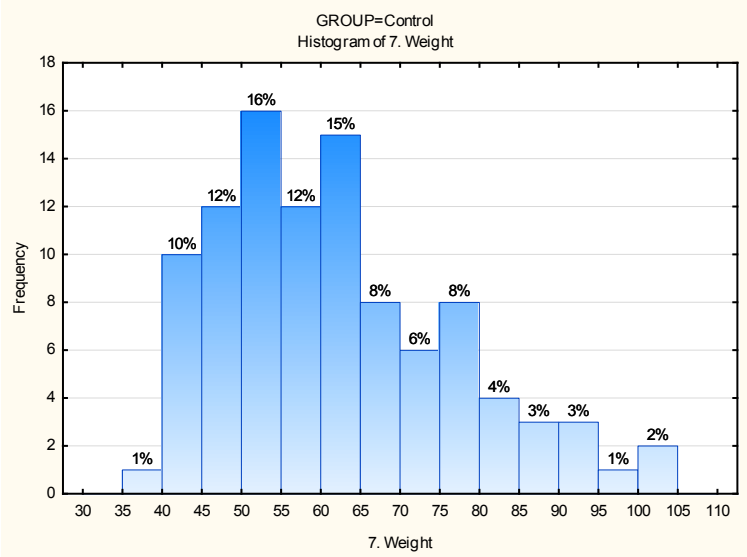

Figure 4.11: Maternal weight of control group

It is clear from the findings discussed in the above section that the mean age for the case group was 22.9 years and the control group was 24.4 years (Tables 4.1 and 4.2). All the participants were coloured people. The majority of participants of both groups were gravida one and nulliparous. There was a cumulative count of 18 (n=18) pregnancy losses throughout this study. The most frequent height of the participants was in the range of 1.58 to 1.60 meters (Figure 4.8) in the case group and 1.55 to 1.60 meters in control group (Figure 4.9). The most frequent weight of the participants in the case group was 51 to 60 kilograms and 50 to 54 kilograms in the control group (Figures 4.10 and 4.11).

4.2.3 Section B: Heart rate as derived from the Monica AN24™ recordings (MHR)

In this section the information relating to the study sample in terms of data that was derived from the Monica AN24™ recordings of the maternal Monica AN24™ heart rate; basal fetal Monica AN24™ heart rate; success rate of the Monica AN24™ recording; duration of Monica AN24™ recording; date of the Monica AN24™ recording; time last smoked before Monica AN24™ recording; and time of the Monica AN24™ recording was obtained. Data of all the various items was collected unless stated otherwise in the discussion of each.

4.2.3.1 Maternal heart rate as derived from the Monica AN24™ recordings (MHR)

Data of the maternal Monica AN24™ heart rate included the case group (n=102) and the control group (n=102). In each group (case and control) the categories were

divided into continuous heart rate above 100 beats per minute (bpm) all the time; continuous heart rate; tachycardia at the beginning and normal heart rate at the end; tachycardia at the end and normal heart rate at the beginning; fluctuations of the maternal heart rate to above 100 bpm; and fluctuations. However, there were categories where one of the following was not found: fluctuations and tachycardia at the beginning; normal heart rate at the end and tachycardia at the end; normal heart rate at the beginning and other, in either the case or control group. These are not reflected in the frequency tables. In the case group (Table 4.7), the most frequent categories were participants with heart rates fluctuating to above 100 bpm (n=62 or 60.8%) or remaining above 100 bpm for the total duration of the recording (25.4%). In the control group (Table 4.8), the most frequent category was participants that had continuous stable heart rates (n= 62 or 60.8%).

Table 4.7: Maternal heart rate as recorded by Monica AN24™ in case group

Category	Frequency (*f*)	Percentage (%)
C100	26	25.4
C	1	1.0
TB	12	11.8
TE	1	1.0
F100	62	60.8
Total	**n=102**	**100**

*C100 - Continuous heart rate at >100 bpm all the time

*C - Continuous stable heart rate all the time

*TB - Tachycardia at the beginning, normal heart rate at end

*TE - Tachycardia at the end normal heart rate at beginning

*F100 - Fluctuating heart rate at > 100 bpm all the time

Table 4.8: Maternal heart rate as recorded by Monica AN24™ in control group

Category	Frequency (*f*)	Percentage (%)
C100	1	1.0
C	62	60.8
F100	18	17.6
F	21	20.6
Total	**n=102**	**100**

*C100 - Continuous heart rate at >100 bpm all the time

*C - Continuous stable heart rate all the time

*F100 - Fluctuating heart rate at > 100 bpm all the time

*F - Fluctuating heart rate for longer than 10 minutes at a time

4.2.3.2 Basal fetal heart rate as derived from the Monica AN24™ recordings (MHR basal fetal)

Data of the basal fetal heart rate, as derived from the Monica AN24™ recordings, included the case group (n=102) and the control group (n=102). In each group (case and control) the categories were divided into continuous stable heart rate; fluctuations to above 160 bpm; fluctuations; continuous heart rate above 160 bpm all the time; and other. However, categories of which there were no frequency in either case or control group, did not appear in the frequency tables. In the case group (Table 4.9), the most frequent category were participants with basal fetal heart rates fluctuating to above 160 bpm (n=38 or 37.3%). In the control group (Table 4.10), the most frequent category were participants that had continuous basal fetal heart rates (n=43 or 42.2%).

Table 4.9: Basal fetal heart rate as recorded by Monica AN24™ in case group

Category	Frequency (*f*)	Percentage (%)
C	31	30.3
F160	38	37.3
F	30	29.4
O	2	2.0
C160	1	1.0
Total	**n=102**	**100**

*C - Continuous stable heart rate all the time

*F160 - Fluctuating heart rate at > 160 bpm all the time

*F - Fluctuating heart rate for longer than 10 minutes at a time

*O - Other

*C160 - Continuous heart rate at >160bpm all the time

Table 4.10: Basal fetal heart rate as recorded by Monica AN24™ in control group

Category	Frequency (*f*)	Percentage (%)
C	43	42.2
F160	19	18.6
F	37	36.3
O	3	2.9
Total	**n=102**	**100**

*C - Continuous stable heart rate all the time

*F160 - Fluctuating heart rate at > 160 bpm all the time

*F - Fluctuating heart rate for longer than 10 minutes at a time

*O - Other

4.2.3.3 Success rate of Monica AN24™ recording (MHR success rate)

The mean success rate of the Monica AN24™ heart rate recordings was 99.9 % for each of the groups (Table 4.1 and 4.2). The minimum and maximum values for the case group were 97.1% and 100.0% respectively (Table 4.1) with a standard deviation of 0.4. The minimum and maximum values for the control group were 97.9 and 100.0% respectively with a standard deviation of 0.3. According to the analyses of

variance (Table 4.3) and the Mann-Whitney U Test (Table 4.4) the success rate showed no significant difference ($p < 0.05$) between the two groups.

4.2.3.4 Duration of Monica AN24™ recording (MHR duration recording)

Data of the duration of the Monica AN24™ recording included the case group (n=102) and the control group (n=102) (Table 4.1 and 4.2) and both groups (Figure 4.12). The minimum and maximum values for the case group were 30.0 and 100.0 minutes respectively (Table 4.1) with a mean of 53.7 minutes. The minimum and maximum values for the control group were 20.0 and 93.0 minutes respectively (Table 4.2) with a mean of 55.2 minutes. There was a typical standard distribution in both groups (Figure 4.12). The analyses of variance (Table 4.3) revealed that the duration of the Monica AN24™ recording did not differ between the two groups. However as the duration of the recording was normally distributed, the Mann-Whitney U Test (Table 4.4) is not applicable and according to analysis of variance (Table 4.3) it showed no significance.

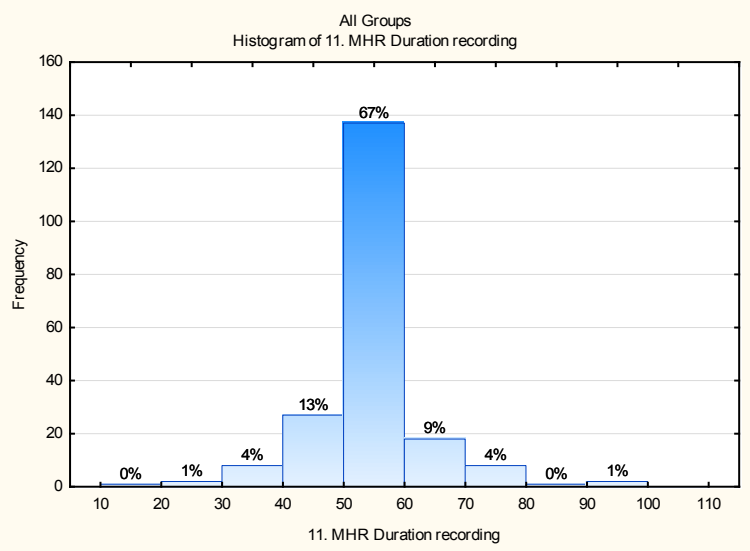

Figure 4.12: Duration of Monica AN24™ recording

4.2.3.5 Date of Monica AN24™ recording (MHR date of recording)

The date of the Monica AN24™ recording includes both groups (n=204), namely the case group (n=102) as well as the control group (n=102). The first selected recording was done on 20 July 2009 and the last selected recording was done on 4 July 2011.

4.2.3.6 Time last smoked before Monica AN24™ recording

The times the last cigarette had been smoked was used to calculate the duration between the last cigarette smoked and the actual recording as recorded by the

Monica AN24™ device. There were 29 smokers in the case group (Figure 14.13) and 37 smokers in the control group (Figure 14.14). The time last smoked before the Monica AN24™ recording was done was only entered into the data collection instrument if the participant had smoked before the recording on the day of recording. The majority of smokers were in the control group (Figures 14.3 and 14.14). Amongst the case group, the majority (n=7 or 24.0%) of participants had their last cigarette before the Monica AN24™ recording between 06h43 and 07h12 (Figure 14.13). Amongst the control group, the majority (n=11 or 30.0%) of the participants had their last cigarette before the Monica AN24™ recording between 06h00 and 7h12 (Figure 14.14).

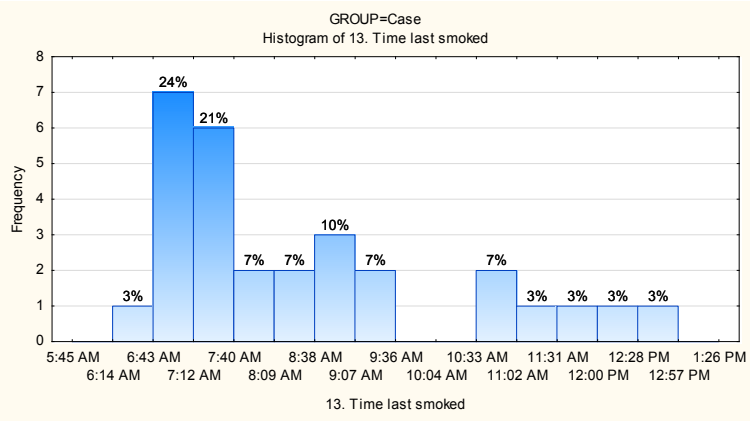

Figure 4.13: Time last smoked before Monica AN24™ recording of case group

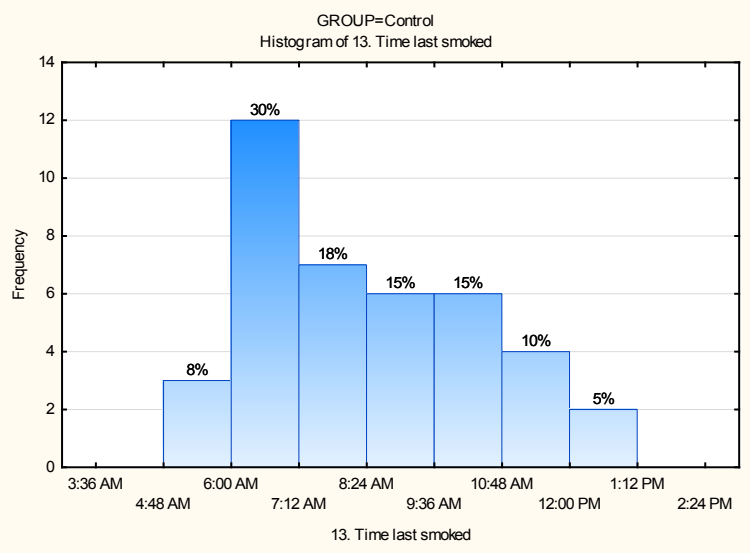

Figure 4.14: Time last smoked before Monica AN24™ recording in control group

4.2.3.7 Time Monica AN24™ recording was done

As mentioned in section 4.2.3.6, the time the last cigarette had been smoked and the time of the recording as recorded by the Monica AN24™ device, were used by the

statistician to calculate the time between the last cigarette smoked and the beginning of the recording. The mean elapsed time between the participants' last cigarette and the commencement of the Monica AN24™ recording was one hour and 39 minutes for the case group and two hours and five minutes for the control group (Table 4.11). Therefore, the case group had a shorter time elapse between the last cigarette smoked and the time the recording started. The results are not normally distributed (Figure 4.15), thus a bootstrap test was done that confirmed that the time difference between the two groups were significantly different (Figure 4.16).

Table 4.11: Time difference between time last cigarette and recording started of both groups individually

Effect	Level of factor	N	Time difference mean	Time difference Standard deviation	Time difference Standard error	Time difference -95.00%	Time difference +95.00%
Total		66	1:54	0:56	0:07	1:40	2:08
Group	Case	29	1:39	0:43	0:08	1:22	1:55
Group	Control	37	2:05	1:03	0:10	1:44	2:27

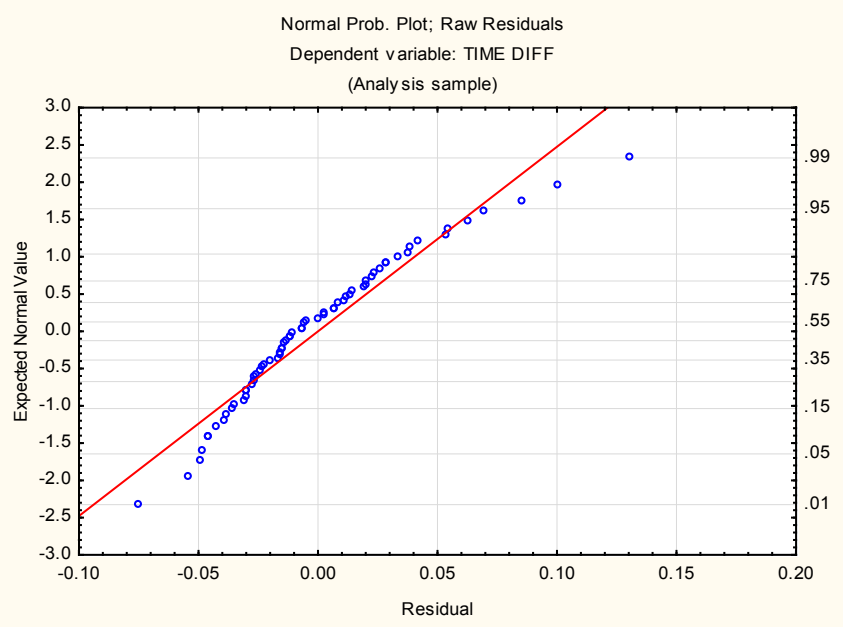

Figure 4.15: Normal probability plot of raw results, demonstrating that the distribution was not normal

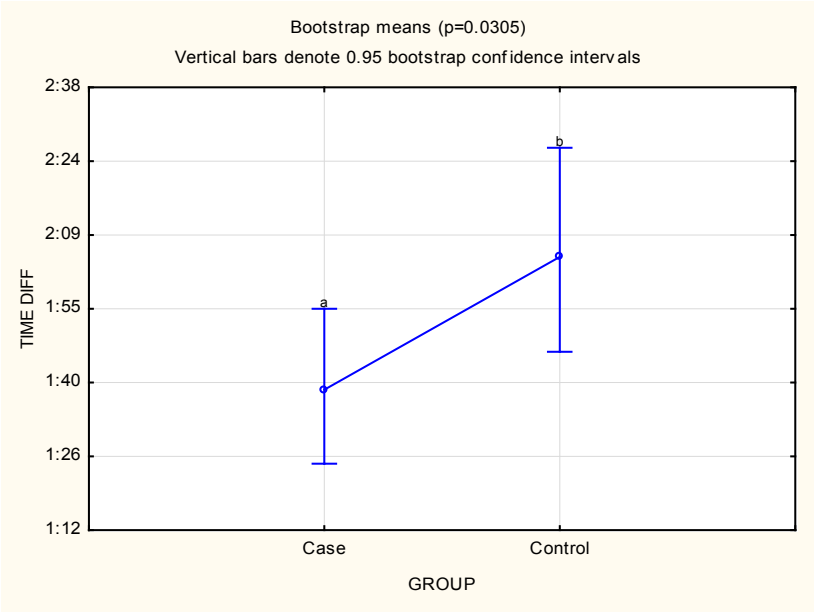

Figure 4.16: Normal probability plot of raw residuals

It is clear from the findings discussed in the above section that the data from the Monica AN24™ recordings revealed that the majority of maternal heart rates in the case group were fluctuating to above 100 bpm (n=62 or 60.8%) and in the control group were participants that had continuous stable heart rates (n=62 or 60.8%). The most frequent category of basal fetal Monica AN24™ heart rate for the case group were participants with basal fetal heart rates fluctuating to above 160 bpm (n=38 or 37.3%)(Table 4.9) and for the control group were participants that had continuous stable heart rates (n=43 or 42.2%)(Table 4.10). From these results it is clear that the majority of control group Monica AN24™ heart rate recordings were continuous stable heart rates with no fluctuations for both the mother and fetus. There was an overall excellent success rate of the quality of the Monica AN24™ recordings for both groups with a minimum recording duration of 20.0 to 100.0 minutes. The participants of both groups had their last cigarettes before the Monica AN24™ recording by 07:12.

4.2.4 Section C: Maternal heart rate recorded antenatally (MHRRA)

In this section the information relating to the study sample in terms of data of the number of antenatal visits; the frequency of maternal heart rate recordings; the maternal heart rate recorded during - the booking visit; - other antenatal visits; - walk-in visits; - referrals; - labour; and post-delivery was obtained. As mentioned previously in section 4.2.3, the data of all the various items was collected unless stated otherwise in the discussion of each.

4.2.4.1 Number of antenatal visits

The total number of participants in both groups where antenatal visits were recorded is 192 (Figure 4.17), namely 93 the case group (Table 4.1) and 99 in the control group (Table 4.2). The data of twelve of the participants were not available, nine in the case group and three in the control group, as the information was incomplete in the copied records. The minimum and maximum number of antenatal visits for the case group were 2.0 and 13.0 respectively (table 4.1) with a mean of 5.9 visits. The minimum and maximum values for the control group were 1.0 and 13.0 antenatal visits respectively (Table 4.2) with a mean of 5.4 visits. The distribution for both groups was slightly skewed left (Figure 4.17). The analyses of variance (Table 4.3) as well as the Mann-Whitney U Test (Table 4.4) did not show a significant difference ($p < 0.05$) between the two groups.

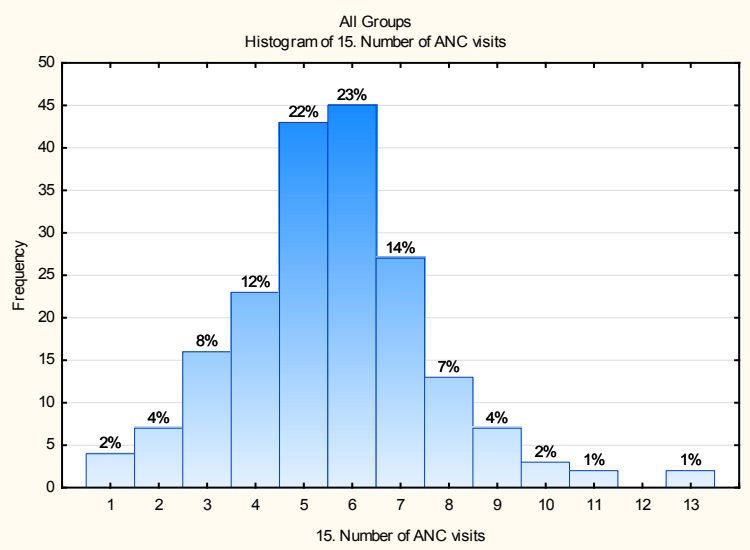

Figure 4.17: Number of antenatal visits

4.2.4.2 Frequency of maternal heart rate recordings

Data of the frequency of maternal heart rate recordings included the case group (n=93) and the control group (n=99) (Table 4.1 and 4.2). As mentioned under section 4.2.4.1, the data of twelve of the participants were not available, nine from the case group and three from the control group, as it was incomplete in the copied records. The minimum and maximum frequency of maternal heart rates recorded for the case group was 1.0 and 69.0 respectively with a mean of 11.7 (Table 4.1). The minimum and maximum frequency of maternal heart rates recorded for the control group was 1.0 and 65.0 respectively with a mean of 9.5 (Table 4.2). According to the analyses of variance (Table 4.3) there was no significant difference ($p < 0.05$) of the frequency of maternal heart rate recordings between the two groups.

4.2.4.3 Maternal heart rate recorded during booking visit (MHRRA booking)

Data of the maternal heart rate recorded during the booking visit included the case group (n=101) and the control group (n=102) (Table 4.1 and 4.2). Only one of the participant's data from the case group was unavailable due to incomplete records. None of the participants' heart rates for the case group (Table 4.1) was recorded at the booking visit. For the control group (Table 4.2) there was only one instance where a participant's heart rate was recorded at the booking visit. This finding was significant, but unfortunately these numbers were too small for statistical analyses.

4.2.4.4 Maternal heart rate recorded during other antenatal visits (MHRRA other ANC visits)

Data of the maternal heart rate recorded during other antenatal visits included the case group (n=101) (Table 4.12) as well as the control group (n=102) (Table 4.13). In the case group the majority of participants' (n=96 or 95.0%) heart rate were never recorded (Table 4.12). There were five participants in the case group where the heart rates were recorded, more than once. In the majority of participants (n=101 or 99.0%) in the control group the heart rate has never been recorded (Table 4.13). There was only one participant where the heart rate was recorded 12 times during other antenatal visits (Table 4.13). The analyses of variance (Table 4.3) and the Mann-Whitney U Test (Table 4.4) did not show a significant difference ($p < 0.05$) of the maternal heart rate recorded during other antenatal visits between the two groups.

Table 4.12: MHRRA other ANC visits of case group

Amount of visits	Frequency (*f*)	Percentage (%)
0	96	95.0
1	2	2.0
3	1	1.0
4	2	2.0
Total	**n=101**	**100**

Table 4.13: MHRRA other ANC visits of control group

Amount of visits	Frequency (*f*)	Percentage (%)
0	101	99.0
12	1	1.0
Total	**n=102**	**100**

4.2.4.5 Maternal heart rate recorded during walk-in visits (MHRRA walk-in visits)

Data of the frequency of maternal heart rate recorded during walk-in visits included the case group (n=94) and the control group (n=100) (Table 4.14 and 4.15). The data of ten of the participants were unavailable, eight from the case group and two from the control group, as it was incomplete in the copied records. In the case group the majority of participants' (n=66 or 70.2%) heart rates were never recorded during walk-in visits (Table 4.14). However, there were 28 participants (n=28 or 29.8%) from the case group where their heart rates were recorded during walk-in visits, the table below highlights the instances of these visits. In the control group the majority of participants' (n=75 or 75.0%) heart rates were never recorded during walk-in visits (Table 4.15). However, there were 25 participants (n=25 or 25.0%) from the control group where their heart rates were recorded during walk-in visits more than once (Table 4.15). The analyses of variance (Table 4.3) and the Mann-Whitney U Test (Table 4.4) both did not show a significant difference ($p < 0.05$) of maternal heart rate recorded during walk-in visits.

Table 4.14: MHRRA walk-in visits of case group

Amount of visits	Frequency (*f*)	Percentage (%)
0	66	70.2
1	20	21.3
2	4	4.2
3	2	2.1
10	1	1.1
17	1	1.1
Total	**n=94**	**100**

Table 4.15: MHRRA walk-in visits of control group

Amount of visits	Frequency (*f*)	Percentage (%)
0	75	75.0
1	21	21.0
2	3	3.0
4	1	1.0
Total	**n=100**	**100**

4.2.4.6 Maternal heart rate recorded during referrals (MHRRA referrals)

Data of the maternal heart rate recorded during referrals included the case group (n=93) and the control group (n=99) (Table 4.1 and 4.2). The data of twelve of the participants were not available, nine from the case group and three (n=3) from the control group due to incomplete copied records. In the case group most of the participants' (n=52 or 56.0%) heart rates were never recorded during referrals. The most instances (maximum value) where their heart rates were recorded during any referrals were 15.0, which only occurred with one participant. In the control group most of the participants' (n=67 or 67.7%) heart rates were never recorded during referrals. The most instances (maximum value) where their heart rates were recorded during any referrals were 22.0, which only occurred with one participant. The analyses of variance (Table 4.3) showed no significant difference ($p < 0.05$) of heart rate recorded during referrals between the two groups.

4.2.4.7 Maternal heart rate recorded during labour (MHRRA labour)

The discussion of the maternal heart rate recorded during labour included the case group (n=93) and the control group (n=99) (Tables 4.1, 4.2 and Figures 4.18 and 4.19). Data that was lost is the same as explained in section 4.2.4.6. The minimum and maximum values of heart rates recorded during labour for the case group was 0.0 and 22.0 respectively (Table 4.1). The mean heart rate recorded during labour for the case group was 4.6 times with a median of 3.0 times which exceeded the mean of 3.6 times and median of 2.0 times of the control group (Table 4.1 and 4.2). The minimum and maximum values of heart rates recorded during labour for the control group was 0.0 and 23.0 respectively (Table 4.2). Thirty-one (n=31 or 33.0%) of the participants from the case group's heart rates were only recorded once or twice during labour. Forty-seven (n=47 or 47.0%) of the participants from the control group's heart rates were only recorded once or twice during labour. The analyses of variance (Table 4.3) did not show a significant difference ($p < 0.05$) of heart rates recorded during labour between the two groups. However, the Mann-Whitney U Test (Table 4.5) showed a significant difference ($p = 0.00$) of heart rates recorded during labour between the two groups.

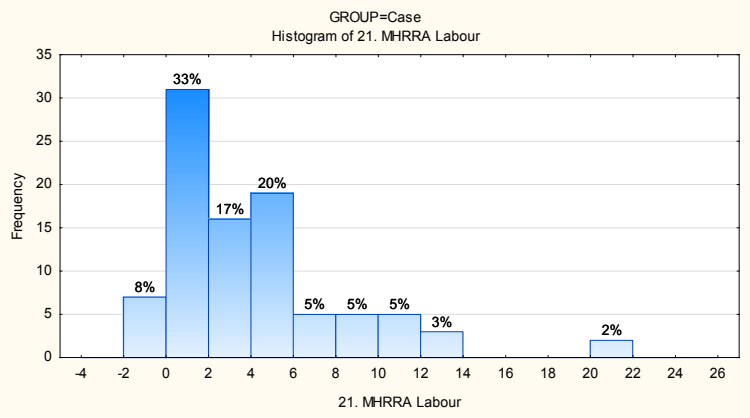

Figure 4.18: Maternal heart rate recordings during labour of case group

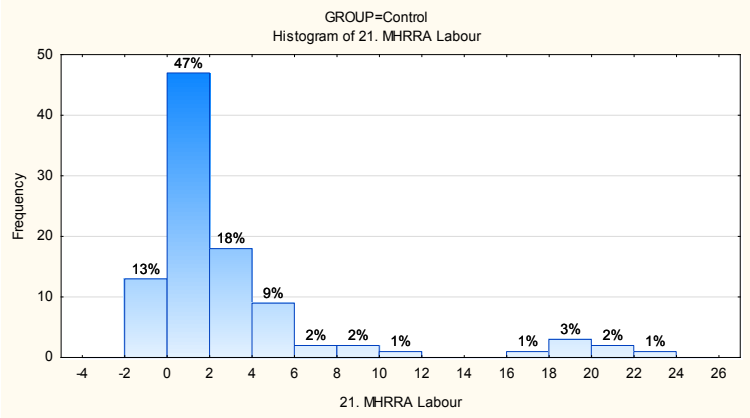

Figure 4.19: Maternal heart rate recordings during labour of control group

4.2.4.8 Maternal heart rate recorded post-delivery (MHRRA post-delivery)

The data of the maternal heart rate recorded post-delivery included the case group (n=93) and the control group (n=99) (Tables 4.1 and 4.2 and Figures 4.20 and 4.21). The same amount of lost data as explained in section 4.2.4.6 applies for this section. Seventy-one (n=71 or 76.0%) of the participants from the case group's heart rates were recorded in the range of one to five times post-delivery. Seventy-two (n=72 or 72.0%) of the participants from the control group's heart rates were recorded in the range of one to five times post-delivery. According to the analyses of variance (Table 4.3) and the Mann-Whitney U Test (table 4.4) there was no significant difference ($p < 0.05$) of heart rates recorded during post-delivery between the two groups.

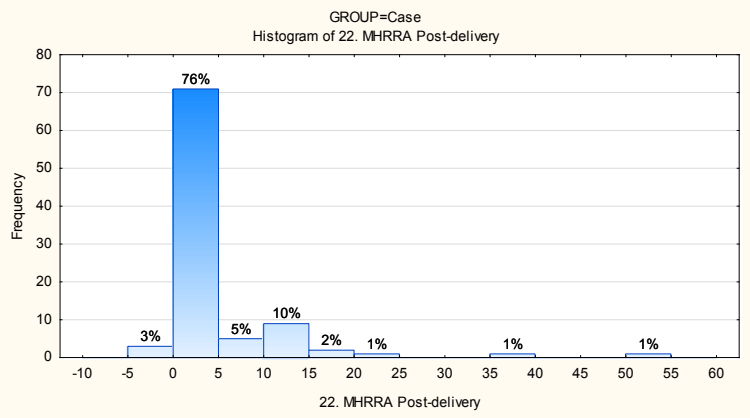

Figure 4.20: Maternal heart rate recordings post-delivery of case group

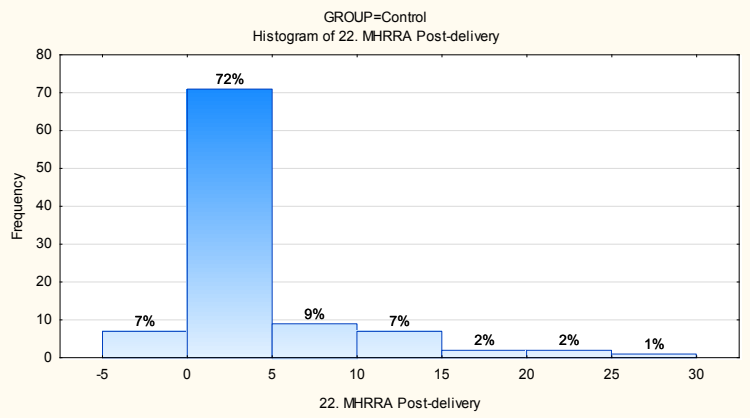

Figure 4.21: Maternal heart rate recordings post-delivery of control group

It is clear from the findings discussed in the above section that the participants from the case group had an average of 5.9 antenatal visits and the control group had an average number of 5.4 antenatal visits throughout the pregnancy. During the entire pregnancy the maternal heart rate was recorded 11.7 times for the case group and 9.5 times for the control group.

4.2.5 Section D: Haemoglobin value

In this section the information relating to the study sample in terms of the data of the haemoglobin (Hb) values recorded at the booking visit; 28 to 38 weeks; delivery; and the frequency of Hb-values done during the entire antenatal period was obtained. All the data of the various items was collected unless stated otherwise, in the discussion of each.

4.2.5.1 Haemoglobin value at booking visit

The Hb-value at the booking visit included the case group (n=89) and the control group (n=93) (Tables 4.1 and 4.2, Figures 4.22 and 4.23). The data of twenty-two

(n=22) of the participants were not available due to incomplete copied records, thirteen (n=13) from the case group and nine (n=9) from the control group. The minimum and maximum Hb-values recorded for the case group was 8.5 and 16.5 g/dL respectively with a mean of 12.0 g/dL (Table 4.1). The minimum and maximum Hb-values recorded for the control group was lower than that of the case group with 8.1 and 15.3 g/dL respectively and also with a mean of 12.0 g/dL (Table 4.2). There was a typical standard distribution in both the case and control groups (Figures 4.22 and 4.23). According to the analyses of variance (Table 4.3) and the Mann-Whitney U Test (Table 4.4) there was no significant difference ($p < 0.05$) of the frequency of the Hb-value recorded at the booking visit between the two groups.

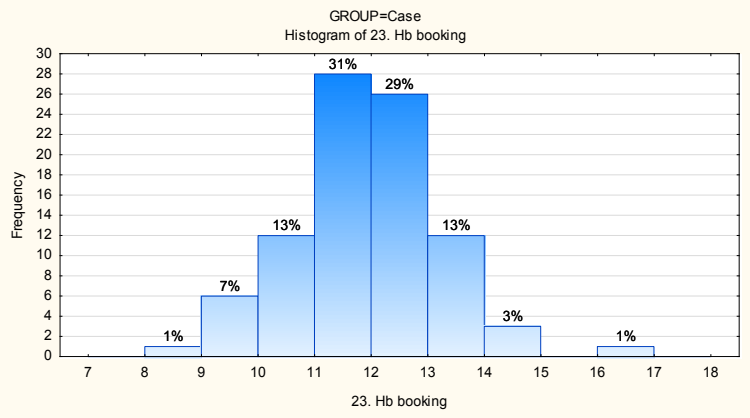

Figure 4.22: Hb value at booking visit of case group

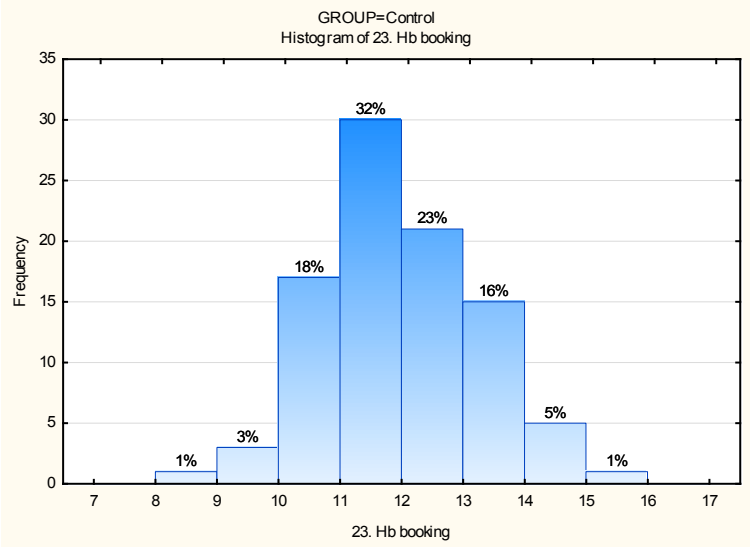

Figure 4.23: Hb value at booking visit of control group

4.2.5.2 Haemoglobin value at 28 to 38 weeks

The data of 51 (n=51) of the participants were not available, seventeen (n=17) from the case group and 34 (n=34) from the control group, as it was not recorded onto the

maternal records. The minimum and maximum Hb-values recorded for the case group was 7.0 and 14.0 g/dL respectively with a mean of 10.7 g/dL (Table 4.1). Almost a third (n=27 or 32.0%) of participants' Hb-values were between 9.1 and 10.0 g/dL (Figure 4.24). The minimum and maximum Hb-values recorded for the control group was 8.0 and 14.0 g/dL respectively with a mean of 10.8 g/dL (Table 4.2). Seventeen (n=17 or 25.0%) participants' Hb-values were between 9.5 and 10.0 g/dL (Figure 4.25). The lowest Hb-value of 7.0 g/dL of the case group was thus lower than that of the control group (Table 4.1). The analyses of variance (Table 4.3) and the Mann-Whitney U Test (Table 4.4) confirmed that there was no significant difference ($p < 0.05$) of the frequency of the Hb-value recorded at 28 to 38 weeks between the two groups.

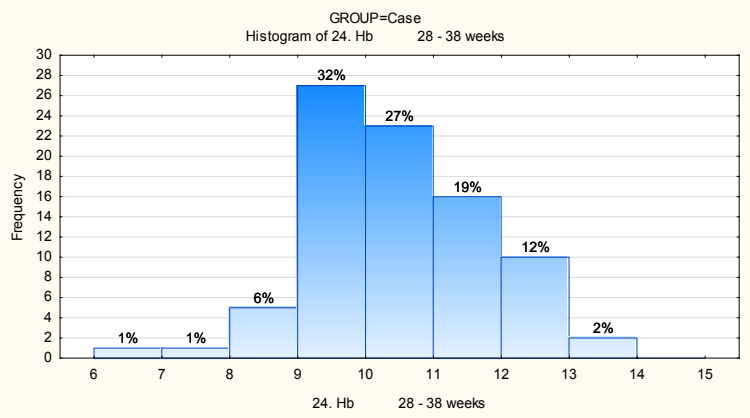

Figure 4.24: Hb value at 28 to 38 weeks of case group

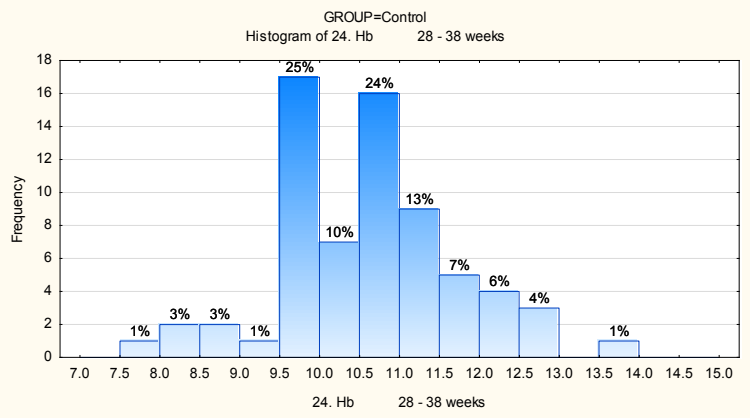

Figure 4.25: Hb value at 28 to 38 weeks of control group

4.2.5.3 Haemoglobin value at delivery

At delivery only 46 (n=46) of the participants from the case group and 31 (n=31) of the participants from the control group's Hb-values were recorded. The minimum and maximum Hb-values recorded for the case group was 7.1 and 15.5 g/dL respectively

with a mean of 10.5 g/dL (Table 4.2). The minimum and maximum Hb-values recorded for the control group was 6.8 g/dL and 14.7 g/dL respectively with a mean of 11.0 g/dL (Table 4.1). According to the analyses of variance (Table 4.3) and the Mann-Whitney U Test (table 4.4) there was no significant difference ($p < 0.05$) of the frequency of the Hb value recorded at delivery between the two groups.

4.2.5.4 Frequency of haemoglobin values done during entire antenatal period

The data of the frequency of Hb-values included 91 (n=91) of the participants from the case group and 95 (n=95) of participants from the control group's Hb-values that were recorded. The remaining 11 (n=11) for the case group and seven (n=7) for the control group's records were incomplete. The frequency of Hb's done for the case group ranged from zero to six times (Figure 4.26). Just over a third (n=34 or 37.0%) of participants from the case group's Hb's were recorded twice and the distribution was typically standard (Figure 4.26). The frequency of Hb's done for the control group ranged from zero to 5 times (Figure 4.27). The majority of participants' Hb's were done twice or three time with a bimodal distribution of 34 (n=34 or 36.0%) (Figure 4.27). The median for the number of Hb examinations in both groups was 3, but the mean in the case group was 2.9 and in the control group 2.5. The analyses of variance (Table 4.3) and the Mann-Whitney U Test (Table 4.4) both revealed a significant difference ($p < 0.05$) of the frequency of Hb values done during the entire antenatal period between the two groups.

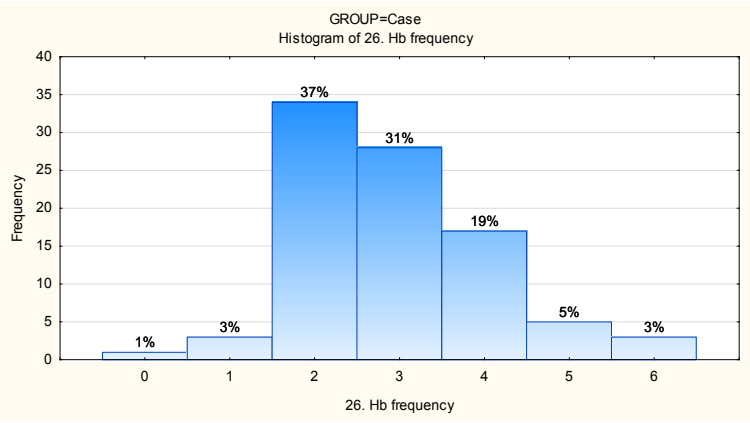

Figure 4.26: Hb frequency of case group

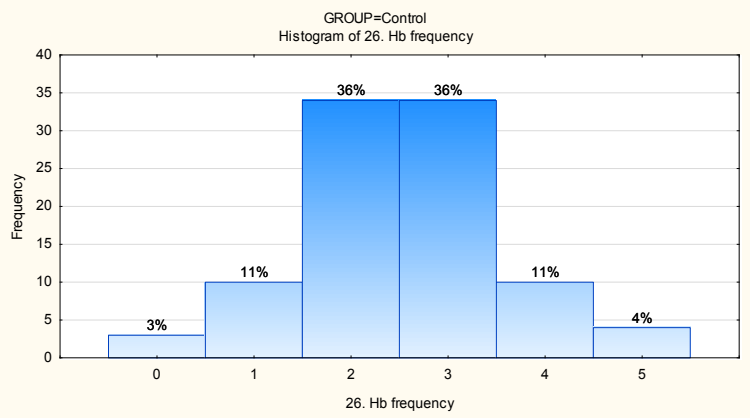

Figure 4.27: Hb frequency of control group

The abovementioned findings of this section will further be discussed in chapter 5.

4.2.6 Section E: Maternal outcome

In this section the information relating to the study sample in terms of the data of the facility of delivery; mode of delivery; pre-existing conditions; maternal morbidity; and maternal mortality was obtained. All the data for the various items were collected unless it was stated otherwise in the discussion of each.

4.2.6.1 Facility of delivery

The data for the facility of delivery of one of the participants from the case group was incomplete. Most of the participants (n=52 or 51.0%) from the case group delivered at a Midwife Obstetric Unit (MOU) (Figure 4.28). Also from the case group, 40 participants (n=40 or 40.0%) of the participants delivered at Karl Bremer Hospital (KBH), only nine (or 9.0%) participants delivered at Tygerberg Hospital. No (n=0 or 0.0%) deliveries of the case group occurred at other facilities. The majority of participants from the control group (n=63 or 62.0%) delivered at a MOU (figure 4.29), which is 11.0% more than that of the case group. Twenty-six (25.0%) participants of the control group delivered at KBH, ten (n=10 or 10%) at Tygerberg Hospital and only three participants (n= 3 or 3.0%) delivered at other facilities.

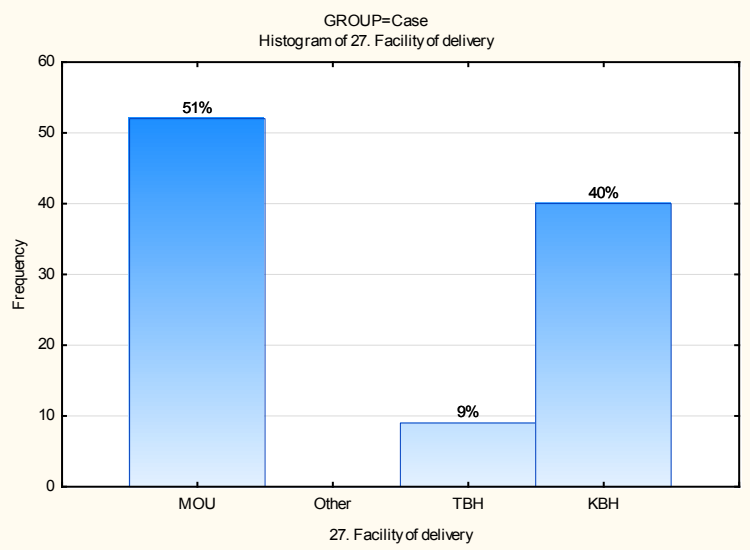

Figure 4.28: Facility of delivery of case group

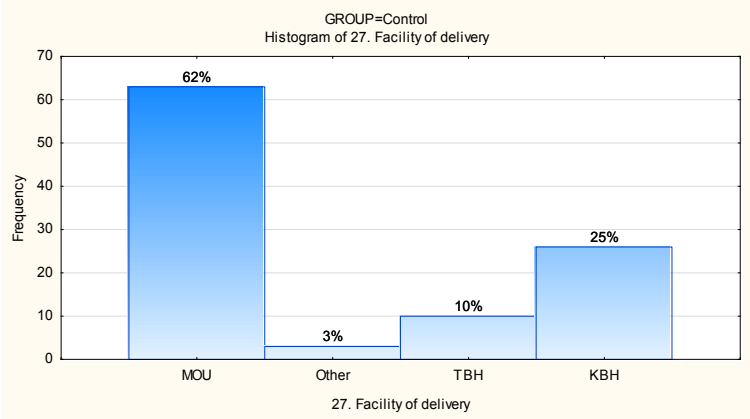

Figure 4.29: Facility of delivery of control group

4.2.6.2 Mode of delivery

The outcome of the mode of delivery was similar for the case and the control groups. The majority of participants for both the case (n=85 or 83.3%) (Table 4.16) and control group (n=86 or 84.3%) (Table 4.17) had normal vertex deliveries. Fifteen (n= 15 or 14.7%) participants from both the case and control groups had caesarean sections (Tables 4.16 and 4.17). One (n=1 or 1.0%) participant from each, the case and control groups had a vaginal breech delivery (Tables 4.16 and 4.17). Only one (n=1 or 1.0%) (Table 4.16) participant from the case group had a forceps delivery. There were no (n=0 or 0.0%) vacuum extractions in any of the groups.

Table 4.16: Mode of delivery of case group

Mode of delivery	Frequency (*f*)	Percentage (%)
Normal vertex delivery	85	83.3
Vaginal breech delivery	1	1.0
Caesarean section	15	14.7
Forceps delivery	1	1.0
Total	**n=102**	**100**

Table 4.17: Mode of delivery of control group

Mode of delivery	Frequency (*f*)	Percentage (%)
Normal vertex delivery	86	84.3
Vaginal breech delivery	1	1.0
Caesarean section	15	14.7
Total	**n=102**	**100**

4.2.6.3 Pre-existing conditions

One participant from the case group and one participant from the control group's data was incomplete from the copied records. The categories for this outcome were divided into coronary artery disease; myocardial infarction; cardiomyopathy; valvular and congenital heart disease; other; and healthy. The majority (n=90 or 90.0%) of participants from the case group were healthy and only 11 (n=11 or 11.0%) of this group were categorised as "other". The group in the "other" category had diseases such as chronic hypertension, asthma, renal disease, drug addiction and HIV. Most (n=86 or 86.0%) of the participants from the control group were healthy and only 15 (n=15 or 15.0%) of this group were categorised as "other". None of the participants from both the case and control group had coronary artery disease; myocardial infarction; cardiomyopathy; valvular heart disease; or congenital heart disease. Thus, there were no pre-existing cardiac conditions diagnosed during the course of this study.

4.2.6.4 Maternal morbidity

The data of nine participants from the case group and four participants from the control group were unavailable due to incomplete records. The categories for this outcome were divided into anaemia; cardiac disease; cardiac complications; infection;

and haematological conditions; other; and healthy. The results of maternal morbidity were similar for the case and the control group. More than half (n=50 or 54.0%) of the participants from the case group (Figure 4.30) were healthy which was less than the control group (Figure 4.31) that was just over two thirds (n=66 or 67.0%). Of the case group 15% (n=14) had “other” health complications; 18% (n=17) had infection; 10% (n=9) were diagnosed with anaemia; and three percent (n=3) had haematological conditions such as severe haemorrhage. Of the control group 12.0% (n=12) had “other” health complications; nine percent (n=9) had infection; eight percent (n=8) were diagnosed with anaemia; and three percent (n=3) had haematological conditions such as severe haemorrhage.

A summary of a number of participants diagnosed with infection after the Monica AN24™ recording was done and is displayed in Table 4.18. The most common possible origin of infection was the operation as indicated by post-operative temperature spikes. The other possible origin of infections such as pyeloniphritis and chorioamnionitis were also prevalent. This table displays the most common possible origins of infection that was diagnosed after the Monica AN24™ recording was done.

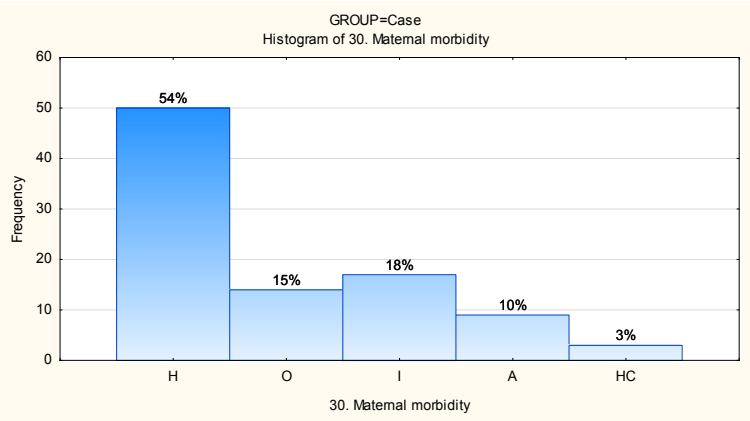

Figure 4.30: Maternal morbidity of case group

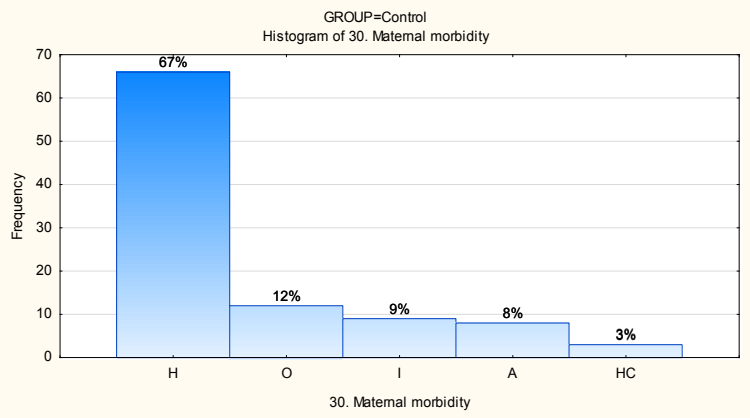

Figure 4.31: Maternal morbidity of control group

Table 4.18: Summary of participant's with infection diagnosed after Monica AN24™ recording

No	Pat ID	Case/ Control	Date when Monica AN24™ recording was done	Date infection was diagnosed	Time from Monica AN24™ recording to diagnosis of infection	Possible origin of infection	Indication for cesarean section	Date of Delivery	Time passed from infection diagnosed to *DOB
29	01896	Case	23/02/2010	09/03/2010	2 weeks	Pyelonephritis	Not applicable	13/03/2010	4 days
55	02058	Case	06/05/2010	16/06/2010	6 weeks	Leucocytes in urine	Poor progress	17/06/2010	1 day
62	02007	Case	14/04/2010	13/06/2010	4 weeks, 1 day	Post-operative temperature spike; no diagnosis	Cephalopelvic disproportion	13/06/2010	Same day
63	01980	Control	14/05/2010	28/06/2010	6 weeks, 3 days	Post-operative temperature spike; no diagnosis	Poor progress	27/06/2010	1 day after DOB
65	02152	Case	20/05/2010	15/06/2010	3 weeks, 5 days	Chorioamnionitis	Not applicable	15/06/2010	9 hours
84	02186	Control	02/08/2010	21/09/2010	7 weeks, 1 day	Post-operative temperature spike; no diagnosis	Fetal distress Poor progress	20/09/2010	1 day after DOB
133	02695	Case	04/01/2011	06/02/2011	4 weeks, 5 days	Post-operative temperature spike; no diagnosis	Fetal distress	05/02/2011	1 Day after DOB
135	02617	Case	05/01/2011	09/02/2011	5 weeks	Post-operative temperature spike no diagnoses	Fetal distress	08/02/2011	1 Day after DOB
167	02890	Case	30/03/2011	04/05/2011	5 weeks	Unknown	Not applicable	04/05/2011	Same day

*DOB - Date of birth

4.2.6.5 Maternal mortality

Data collected for maternal mortality for both the case and the control group was categorised as either a “yes” or “no”. The results of the case group equalled those of the control group. Only two participants died, one in the case (1.0%) and one in the control (1.0%) group. At the time of data collection, both 101 (99.0%) participants in the case and 101 (99.0%) participants in the control group were alive.

It is clear from the findings discussed in the above section that the majority of participants had normal vertex deliveries and delivered at a MOU. There were little pre-existing conditions listed as “other” in participants from the case (n=11 or 11.0%) and control group (n=15 or 15.0%). There were various maternal complications (refer to section 4.2.6.4) and only 1.0% maternal mortalities for each group.

4.2.7 Section F: Neonatal outcome

The information relating to the study sample in terms of data recorded of the neonatal gender; neonatal morbidity; neonatal mortality; birth weight; gestational age at delivery; and small for gestational age was obtained in this section. Unless stated otherwise at each item, all the data of the various items were collected.

4.2.7.1 Neonatal gender

The discussion of neonatal gender included each group, namely the case group (n=102) and control group (n=102) individually. Fifty-five percent (n=56) were female babies and 45% (n=46 or 45.0%) were male babies from the case group. Of the control group 49.0% (n=50) were female babies and 51.0% (n=52) were male babies.

4.2.7.2 Neonatal morbidity

The data of eight participants from the case group and two (n=2) participants from the control group were unavailable due to incomplete records. The categories for neonatal morbidity were divided into respiratory distress syndrome; infection; neonatal jaundice; other; and healthy. The majority (n=87 or 92.6%) of babies from the case group were healthy at the time data was collected, 1.1% (n=1) of babies were categorised as “other” (congenital cardiac lesion), 4.2% (n=4) of babies had respiratory distress syndrome and 2.1% (n=2) of babies had neonatal jaundice (Table 4.19). No baby in the case group was diagnosed with infection at the time data was collected. Most babies (n=90 or 90.0%) from the control group were healthy at the time data was collected, 4.0% (n=4) of babies were categorised as “other” (IUGR, congenital cardiac lesion and thrombocytopaenia), 1.0%

(n=1) of babies had respiratory distress syndrome, 4.0% (n=4) were diagnosed with neonatal jaundice and 1.0 (or 1.0%) of babies had infection (Table 4.20).

Table 4.19: Neonatal morbidity in case group

Category	Frequency (*f*)	Percentage (%)
Healthy	87	92.6
Other	1	1.1
Respiratory distress syndrome	4	4.2
Neonatal jaundice	2	2.1
Total	**n=94**	**100**

Table 4.20: Neonatal morbidity in control group

Category	Frequency (*f*)	Percentage (%)
Healthy	90	90.0
Other	4	4.0
Respiratory distress syndrome	1	1.0
Neonatal jaundice	4	4.0
Infection	1	1.0
Total	**n=100**	**100**

4.2.7.3 Neonatal mortality

Data collected for neonatal mortality for both the case and the control group was categorised as either a “yes” or “no”. The data of one of the participants were incomplete; therefore it could not be collected. The categories for neonatal mortality were divided into alive; miscarriage; intra-uterine death; neonatal death; and infant death. Almost all the babies (n=101 or 99.0%) in the case group’s participants were alive at the time the data was collected. Only one baby from a participant (or 1.0%) in the case group had a neonatal death due to a congenital cardiac lesion. The control group had 99 (n=99 or 98%) babies that were alive at the time data collection was completed; there were one (1.0%) infant death due to a congenital cardiac lesion and one (1.0%) neonatal death due to IUGR.

4.2.7.4 Birth weight

Although each individual birth weight was typed into the spreadsheet, the birth weight was expressed in groups of 500g on the histograms of each group (Figures 4.32 and 4.33). In

the case group the birth weight ranged from 2000g to 5000g. Almost half of the neonates (n=48 or 47.0%) in the case group weighed between 3000g and 3499g (Figure 4.32) and nearly a third of the neonates (n=30 or 29.0%) weighed between 2500g and 2999g. In the control group the birth weight ranged from 1000g to 4500g (Figure 4.33). There was a typical standard distribution of birth weights in the control group (Figure 4.33). About a third of the neonates (n= 34 or 33.0%) from the control group weighed between 3000g and 3499g and almost a third of the neonates (n=30 or 29.0%) weighed between 2500g and 2999g (Figure 4.33). According to the analyses of variance (Table 4.3) there was a significant difference ($p < 0.05$) of the birth weight between the two groups, as the mean birth weight in the case group was 3226g and 3032g in the control group (Table 4.21).

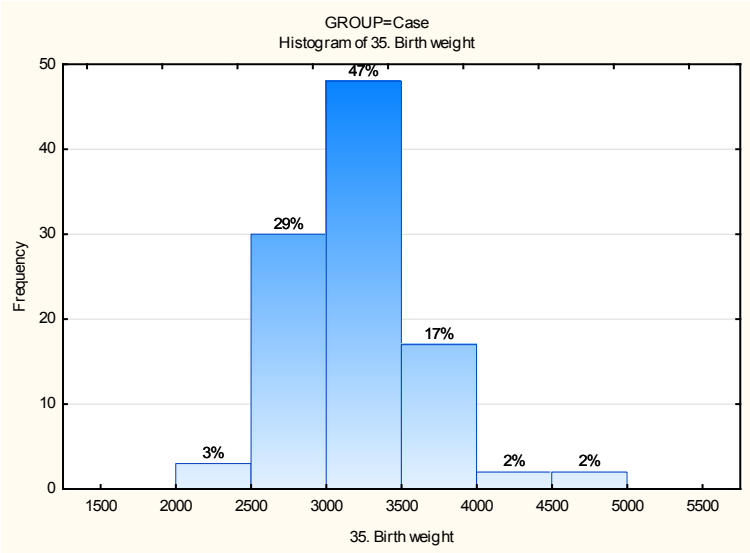

Figure 4.32: Birth weight of case group

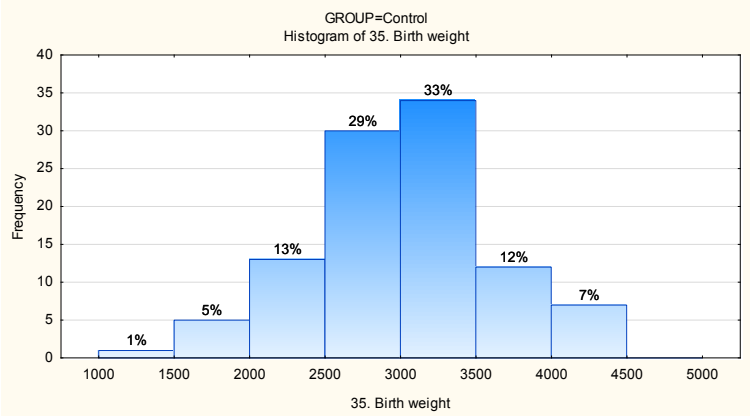

Figure 4.33: Birth weight of control group

4.2.7.5 Gestational age at delivery

Although the information on gestational age at delivery was collected in weeks and days separately the data of only the completed weeks are displayed and discussed in this

section (Figures 4.34 and 4.35). The gestational age in weeks for the case group ranged from 36 weeks (n=2 or 2.0%) to 42 weeks (n=5 or 5.0%) with a mean and median of 39.2 and 39 weeks respectively (Figure 4.34 and Table 4.1). The majority of participant's from the case group delivered at 39 weeks (n=28 or 27.0%). The gestational age in weeks for the control group ranged from 34 weeks (n=1 or 1%) to 42 weeks (n=6 or 6%) with a mean and median of 38.9 and 39 weeks respectively (Figure 4.35 and Table 4.2). The majority of participants from the control group delivered at 40 weeks (n=23 or 23.0%). According to the analyses of variance (Table 4.3) the groups did not differ significantly. As summarised in Table 4.21, there was little difference in the gestational age, but a greater significance in birth weight according to the Mann-Whitney U Test.

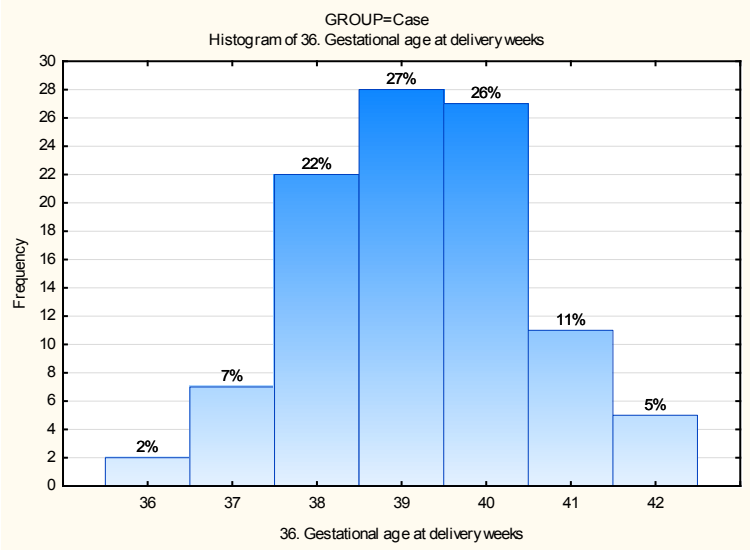

Figure 4.34: Gestational age at delivery in weeks of case group

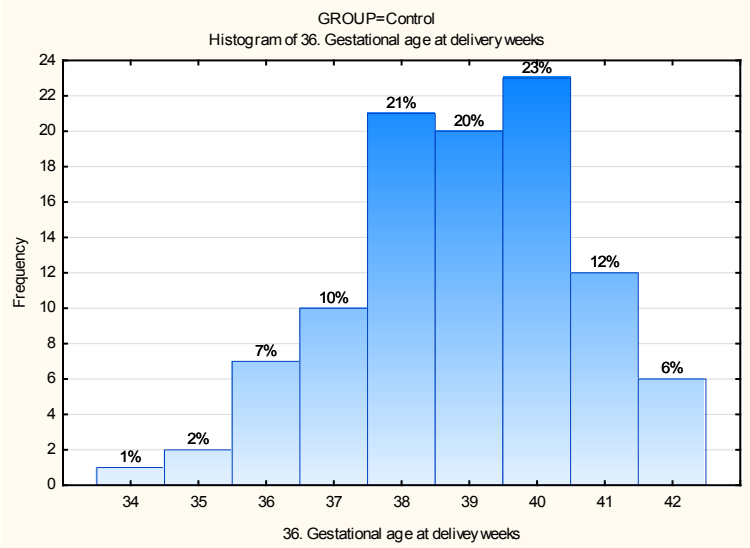

Figure 4.35: Gestational age at delivery in weeks of control group

Table 4.21: Compared findings of gestational age, birth weight and p-value of Mann-Whitney U Test

	Case	Control	Mann-Whitney U Test p-value
GA weeks (mean)	39.2	38.9	0.27
Birth weight (mean)	3226 g	3032 g	0.02

4.2.7.6 Small for gestational age (SGA)

Based on the birth weight and the gestational age at delivery, it could be determined whether the neonates were small for gestational age. The data collected for this variable was based on the single centile chart designed for the population of the Western Cape (Theron & Thompson, 1995:1291). Only 5.9% (n=6) of neonates from the case group were small for their gestational age and 94.1% (n=96) were not small for their gestational age (Table 4.22). Almost a fifth (n=20 or 19.6%) of neonates from the control group were small for their gestational age and 80.4% (n=82) were not small for their gestational age (Table 4.23).

Table 4.22: Small for gestational age of case group

Small for gestational age	Frequency (*f*)	Percentage (%)
No	96	94.1
Yes	6	5.9
Total	**n=102**	**100**

Table 4.23: Small for gestational age of control group

Small for gestational age	Frequency (*f*)	Percentage (%)
No	82	80.4
Yes	20	19.6
Total	**n=102**	**100**

It is clear from the findings discussed in the above section that the majority of neonates in both groups were healthy. There was an overall mortality of 3.0% in both groups. There was a difference in mean birth weight of 194g between the two groups. Further discussion regarding the birth weight continues in chapter 5.

4.2.8 Section G: Apgar scores

The information relating to the study in terms of Apgar scores one minute, five minutes and ten minutes was obtained in this section. All the data of the various items in this section were collected unless stated otherwise.

4.2.8.1 Apgar score at one minute

Data of the Apgar scores at one minute included the case group (n=102) and the control group (n=97). Five of the participants from the control group's data were unavailable due to incomplete records. The options of values for the Apgar scores were on a scale from one to ten. Value one was the lowest and value ten was the highest score. The results of the Apgar scores for the case group ranged from five to ten. The majority (n=86 or 84.3%) from the case group scored nine out of ten at one minute (Table 4.24). The results of the Apgar scores for the control group ranged from two to nine. Most (n=84 or 87%) participants from the control group also scored nine out of ten (Table 4.25). The mean Apgar score was 8.8 for the case group and 8.7 for the control group. The analyses of variance (Table 4.3) and the Mann-Whitney U Test (table 4.4) all showed that there was no significant difference ($p < 0.05$) of the Apgar scores at one minute between the two groups.

Table 4.24: Apgar score at one minute of case group

Apgar score	Frequency (*f*)	Percentage (%)
5	2	2.0
6	2	2.0
7	1	1.0
8	8	7.8
9	86	84.3
10	3	2.9
Total	**n=102**	**100**

Table 4.25: Apgar score at one minute of control group

Apgar score	Frequency (*f*)	Percentage (%)
2	1	1.0
5	2	2.0
6	1	1.0
8	9	9.0
9	84	87.0
Total	**n=97**	**100**

4.2.8.2 Apgar score at five minutes

The data of the Apgar scores at five minute included the case group (n=102) and the control group (n=97). Five of the participants from the control group's data were also unavailable due to incomplete records. The arrangement of scoring is the same as explained in section 4.2.8.1. The results of the Apgar scores at five minutes for the case group ranged from six to ten. Most (n=87 or 85.3%) participants in the case group scored ten out of ten for their five minute Apgar score (Table 4.26). The results of the Apgar scores at five minutes for the control group ranged from two to ten. The majority (n=87 or 90.0%) of participants in the control group also scored ten out of ten at their five minute Apgar score (Table 4.27). The mean Apgar score was 9.8 for both groups. The analyses of variance (Table 4.3) revealed no significant difference ($p < 0.05$) of the Apgar scores at five minutes between the two groups. However, the Mann-Whitney U Test (table 4.4) showed that there was a significant difference ($p < 0.05$) of the Apgar scores at five minutes between the two groups.

Table 4.26: Apgar score at five minutes of case group

Apgar score	Frequency (*f*)	Percentage (%)
6	1	1.0
8	3	2.9
9	11	10.8
10	87	85.3
Total	**n=102**	**100**

Table 4.27: APGAR score at five minutes of control group

Apgar score	Frequency (*f*)	Percentage (%)
2	1	1.0
8	1	1.0
9	8	8.0
10	87	90.0
Total	**n=97**	**100**

4.2.8.3 Apgar score at ten minutes

Data of the Apgar scores at ten minutes included the case group (n=51) and the control group (n=49). The data of 50 participants from case group and 53 participants from the control group were unavailable due to incomplete records. The arrangement of scoring is the same as explained in section 4.2.8.1. The results of the Apgar scores at ten minutes for the case group ranged from eight to ten. The results of the majority (n=48 or 94.1%) of data for the case group scored ten out of ten for the ten minute Apgar score. The results of the Apgar scores at ten minutes for the control group ranged from one to ten. The results of most (n=47 or 96.0%) of data for the control group also scored ten out of ten for the ten minute Apgar score. The mean Apgar score was 9.9 for the case group and 9.8 for the control group. The analyses of variance (table 4.3) as well as the Mann-Whitney U Test (table 4.4) revealed no significant difference ($p < 0.05$) of the Apgar scores at ten minutes between the two groups.

It is clear from the findings discussed in the above section that the overall majority of Apgar scores were good. The low Apgar scores were in the minority of cases.

4.2.9 The prevalence of maternal tachycardia in late pregnancy

The overall prevalence of maternal tachycardia was calculated by dividing the total number of participants who presented with maternal tachycardia (n=102 case group) through the total number of Monica AN24™ recordings that were analysed (total target population N=1431). Therefore the calculated percentage of the prevalence rate of maternal tachycardia in late pregnancy for this ancillary study is 7.1% rounded off to the first decimal.

4.3 CONCLUSION

The data collected in this study was analysed and discussed in chapter 4. The researcher succeeded in successfully exploring and achieving the following objectives designed for this study, i.e.:

The prevalence of maternal tachycardia at 34 to 38 weeks gestation in a sub-population of patients enrolled in the Safe Passage Study was determined. The empirical findings with a control group of normal maternal heart rates during late pregnancy were compared. The presence of anaemia in both groups were determined and compared. Any underlying pre-existing conditions as well as pre-existing cardiac conditions were explored and the perinatal outcomes of the participants were determined.

Chapter 5 includes a further discussion on the synthesis as well as the hypothesis intended for this study. Appropriate recommendations were presented, certain limitations were illustrated and the chapter was brought to an end with a final conclusion.

CHAPTER 5: DISCUSSION, CONCLUSIONS AND RECOMMENDATIONS

5.1 INTRODUCTION

In this chapter, an overview of the key findings is given; conclusions are drawn as to whether maternal tachycardia in late pregnancy is associated with underlying major cardiac disease, maternal anaemia; and adverse maternal and perinatal outcomes. Where appropriate, the findings are measured and compared with previous studies in the same field.

Suitable recommendations are given as identified by the researcher and experts in the field of study. A number of limitations of this study are highlighted in this chapter and the latter is ended off with a final conclusion.

5.2 DISCUSSION AND CONCLUSIONS

The findings of maternal tachycardia in this study supports the view held by Reide and Yentis (2010:315) referred to in section 2.3 that in women with tachycardia and arrythmias, the symptoms are absent or mild in most cases, however the authors claim that all pregnant women are prone to tachycardia and arrythmias which does not completely agree with this study's findings of a 7.1 % (n=102) prevalence of maternal tachycardia.

Referring to section 2.4.5.9, the results of Carson *et al*.'s (2002:42) study to determine the effect of obesity and position on heart rate in pregnancy confirmed that more women are tachycardic when in the seated position (39%) than when on their left side (29%; $p<0.001$). The abovementioned study also concluded that the women that presented with tachycardia also had a higher BMI. As mentioned in section 4.2.2.7 the findings of maternal weight for this study did not reveal any significant difference between the participants with maternal tachycardia and those that had normal heart rates. Although Carson *et al*.'s (2002:42) study proved significant findings, in context of the findings of maternal weight; no significance could be established in this study.

5.2.1 Significant findings according to the Mann-Whitney U Test

As shown in various analyses, the data was often not normally distributed. Under these circumstances the non-parametric Mann-Whitney U test was used to determine statistical significance. The significant p-values of the Mann-Whitney U test are displayed in table 5.1 and these findings are discussed in the next section at it gives a summary of the most

important findings. This follows with an evaluation and discussion on the hypotheses that were formulated for this study.

Table 5.1: Significant p-value of Mann-Whitney U Test

Variable	Significant p-value
Maternal age	0.04
Gravidity	0.01
Parity	0.00
Duration of Monica AN24™recording	0.00
Frequency of maternal heart rate recordings	0.05
Haemoglobin frequency	0.04
Birth weight	0.02

5.2.1.1 Maternal age, gravidity and parity

A comparison between maternal ages revealed that the case group's participants were younger (mean age of 22.9 years) than the control group's participants (mean age of 24.4 years). As mentioned in section 4.2.2.1 the p-value for the Mann-Whitney U test was 0.04 indicating that there was a significant difference between the case and the control group (Table 5.1).

Illustrated in section 4.2.2.3 and tables 4.1 and 4.2 the mean gravidity of the case group of 1.8 was less than that of the control group of 2.2. The p-value for the Mann-Whitney U test was 0.01 (Table 5.1) indicating a statistical significant difference. The mean parity (refer to section 4.2.2.4 and tables 4.1 and 4.2) for the case group of 0.7 was lower than that of the control group of 1.1. The Mann-Whitney U test revealed that it also differed significantly between the two groups (Table 5.1).

An evaluation of the abovementioned findings, a clear association can be drawn to the maternal age, gravidity and parity. The case group's participants that had maternal tachycardia were younger than the control group's participants. Therefore, the researcher conclude that this explains why the average gravidity and parity was also lower in the case group, it may be because these participants were younger. No obvious reason for this finding of the lower maternal age in the case group could be identified.

The findings of Carson *et al.*'s (2002:42) study revealed no significant difference of maternal age, gravidity and parity in women with normal heart rates compared to women that presented with tachycardia. In the extensive scanning of the literature, no additional

reports could be found where maternal age, gravidity and parity were associated with prevalence of tachycardia during pregnancy.

5.2.1.2 Duration of Monica AN24™ recording (MHR duration recording)

As mentioned in section 4.2.3.4 the average Monica AN24™ recording duration for the case group was 53.7 minutes (Table 4.1) that was less than the average Monica AN24™ recording duration of 55.2 minutes (Table 4.2) of the control group. With a p-value of 0.00 the Mann-Whitney U test (Table 5.1) revealed a statistically significant difference between the two groups. As the data of the duration of the Monica AN24™ recording was actually normally distributed, the analysis of variance (Table 4.3) is considered to be the more statistically appropriate test as no significant difference ($p < 0.05$) was found between the two groups. The difference of less than two minutes between the two groups is, according to the researcher, of little clinical value. In addition, the selection of participants where the duration of the recording had met specific requirements could be the reason why the durations of the recordings were almost similar.

5.2.1.3 Frequency of maternal heart rate recordings

An evaluation of the findings, referring to section 4.2.4.2 and tables 4.1 and 4.2 reveals that the heart rates of participants from the case group were recorded an average of 11.7 times which was more than the average heart rates recorded of the participants from the control group of 9.5 times. This leads to the question, why was maternal heart rate more regularly recorded in the case group? The data was not normally distributed, the median of the case group is 8.0 and the control group is 6.0. The Mann-Whitney U test revealed a p-value of 0.05 (Table 5.1), which proves a statistical significant difference between the two groups.

Although one can argue that some participants in the case group could have presented with more “adverse incidents”, the number of complicated cases such as pre-existing conditions of anaemia were not significantly different in both groups. Therefore, the clinical significance of these findings is in question as no possible reason could be found why the maternal heart rate was recorded more often in the case group. In the extensive scanning of the literature, no report could be found where frequency of pulse rate recordings in normal pregnancies was associated with possible poor outcome.

A Science Direct, Scopus, MD Consult, Cinahl Ebscohost and Pubmed search was done on with the key words: “maternal heart rate recordings”; “frequency of maternal heart rate recordings”; “maternal heart rate”; “maternal tachycardia” revealed limited results for the

time span 2006 to present. No study could be found to compare findings within a comparable context.

5.2.1.4 Haemoglobin value frequency

The mean frequency of recorded haemoglobin (Hb) values for the case group was 2.9 and the control group was 2.5, which means that the Hb-values were recorded an average of 0.4 times more in the case group than in the control group. The Mann Whitney U test showed that there was a statistical significant difference between the two groups with a p-value of 0.04 (Table 5.1).

One can argue that the mean number of antenatal visits which is more in the case group (5.9 times) (Table 4.1) than the control group (5.4 times) (Table 4.2) could have had an effect on the number of times the Hb values were recorded. But the reason for this increase remains uncertain. In addition, from a clinical point of view, the small difference of 0.4 is of little significance.

As mentioned in section 5.2.1.3, a literature search was done on the following databases: Science Direct, Scopus, MD Consult, Cinahl Ebscohost and Pubmed. Keywords such as “frequency of Hb recordings” and “antenatal visits” revealed limited results for the time span 2006 to present. Therefore no research could be found to compare findings in a comparable context of this study.

5.2.1.5 Birth weight

The mean and median birth weight for the case group was 3226g and 3220g respectively (Table 4.1). The mean and median birth weight for the control group was 3032g and 3050g respectively (Table 4.2). The Mann-Whitney U test revealed a statistical significance in birth weight between the two groups.

This finding raises questions as to why there was an increased birth weight in infants whose mothers had tachycardia? Literature findings revealed that the tachycardia increased the maternal cardiac output and therefore could increase uteroplacental blood supply with subsequent increase in fetal requirements. The study of Gelson, Curry, Gatzoulis, Swan, Lupton, Steer and Johnson (2011:887) is a retrospective cohort study done in London to determine the effect of maternal heart disease on fetal growth and neonatal outcomes, the authors contend that a woman’s cardiovascular adaptation to pregnancy is important because it determines the uteroplacental perfusion. Although cardiac disease can be associated with poor nutrition and hypoxia it seems likely that cardiovascular performance is the major influence of fetal growth. Also, this study

furthermore validated that women with cardiac disease are more likely than those in a control population to give birth to newborns with low percentile birth weights at an earlier gestational age which results in a higher rate of perinatal complications in these women. The authors recognised that the strongest predictors of low birth weight and preterm delivery are maternal cyanosis or reduced output or both.

It was decided to list only the significant findings according to the Mann-Whitney U test (Table 5.1), as there were too many negative findings to discuss. The decision to list the duration of recording under table 5.1 could be questioned as the findings were normally distributed. According to the analysis of variance test (Table 4.3) the difference (p=0.22) was not significant.

5.2.2 Hypotheses

The following research hypotheses were formulated for this study in section 1.2.1 in chapter one and discussed as follows.

5.2.2.1 Hypothesis 1: Maternal tachycardia in late pregnancy is associated with underlying major cardiac disease

This hypothesis was designed to determine whether there is an association between maternal tachycardia and underlying major cardiac disease. Referring to section 4.2.6.3 none of the participants from the case and control group have been diagnosed with any of the pre-existing cardiac conditions. There were also no cardiac complications in either group.

As there were no pre-existing cardiac conditions in any of the groups and no cardiac complications during pregnancy and delivery, this hypothesis could not be tested. As the prevalence rate of cardiac disease in pregnancy is particularly rare, a very large study would be needed to test this hypothesis.

5.2.2.2 Hypothesis 2: Maternal tachycardia in late pregnancy is associated with maternal anaemia

This hypothesis was formulated to determine whether there is an association between maternal tachycardia in late pregnancy and maternal anaemia. The results referred to in section 4.2.5.2 and 4.2.6.4 as well as further analyses that are discussed below was considered to determine the abovementioned hypothesised association. The parameters for anaemia in pregnancy have been defined in section 2.2.3. As referred to the section mentioned above, any participant with an Hb-value lower than 11.0 g/dL is considered to be anaemic (Woods, 2006:13).

Reflecting the results for the Hb-value at 28 to 38 weeks, the minimum Hb-values for the case and control groups were 7.0 g/dL and 8.0 g/dL respectively (section 4.2.5.2). The mean and median Hb-values for the case group were 10.7 g/dL and 10.5 g/dL respectively (Table 4.1). The mean and median Hb-values for the control group were 10.8 g/dL and 11.0 g/dL respectively. There was an increased frequency of mild anaemia (Hb-values < 11.0 g/dL) in the case group (55.0%) compared to that of the control group (47.0%). However, the Mann-Whitney U test revealed no statistically significant difference of the Hb-values at 28 to 38 weeks between the case and the control groups.

Reflecting the results of maternal morbidity, the incidence of anaemia in the case group (10%) was more than the control group (8%) (section 4.2.6.4). Further statistical tests were done to compare the findings of the participants Hb-values between 28 to 38 weeks and the participants that had anaemia in the outcome of the study. The box plot below presents the difference between the Hb-values of participants at 28 to 38 weeks and the outcome of anaemia (Figure 5.1). The median for the participants that were not diagnosed with anaemia was 11.0 g/dL and the median Hb-value for the participants that were diagnosed with anaemia was 9.0 g/dL.

A bootstrap test was done which clearly demonstrates a bigger decline in Hb-values in the control group than in the case group (Figure 5.2). The Bonferroni test was applied and confirmed a significant difference (p=0.02) between the two variables of the control group. However, this test confirmed that there was no significant difference (p=0.20) between the two variables of the case group.

The null hypothesis in this instance was accepted as no statistical significant difference could be found to prove that maternal tachycardia in late pregnancy was associated with maternal anaemia. The Hb-values of the participants were done around the time the most participants had their Monica AN24™ recording. Since no statistical significant evidence in this study could be found to substantiate this hypothesis, the researcher concludes that mild maternal anaemia did not have an effect on the maternal heart rate in late pregnancy. Therefore this hypothesis could not be substantiated and was rejected.

According to the guidelines for maternity care in South Africa (Department of Health, 2007), anaemia is classified into two categories, mild anaemia (Hb value of 7.0 to 10.9 g/dL) and severe anaemia (Hb value of less than 7.0 g/dL). As mentioned in the beginning of this section, the mean Hb at 28 to 38 weeks gestation was 10.7 g/dL for the case and 10.8 g/dL for the control groups. The results from this study revealed that there were only cases with mild anaemia during late pregnancy (28 to 38 weeks gestation) and no cases

with severe anaemia. This hypothesis was rejected on the basis that the anaemia cases were not severe in nature but mild. The management of a patient with iron deficiency anaemia in pregnancy suggests that a Hb-value less than 8 g/dL with tachycardia or shortness of breath should be admitted to hospital for a blood transfusion (Woods, 2006:13). This clarifies a severe case of anaemia as it relates to tachycardia during pregnancy.

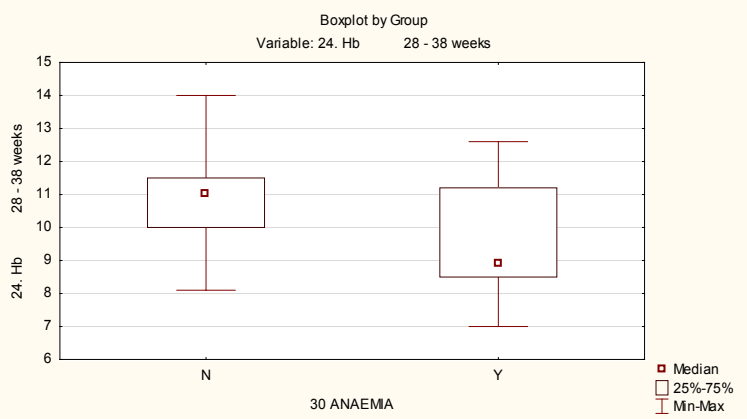

Figure 5.1: Box plot of Hb values of both groups at 28 to 38 weeks versus anaemia

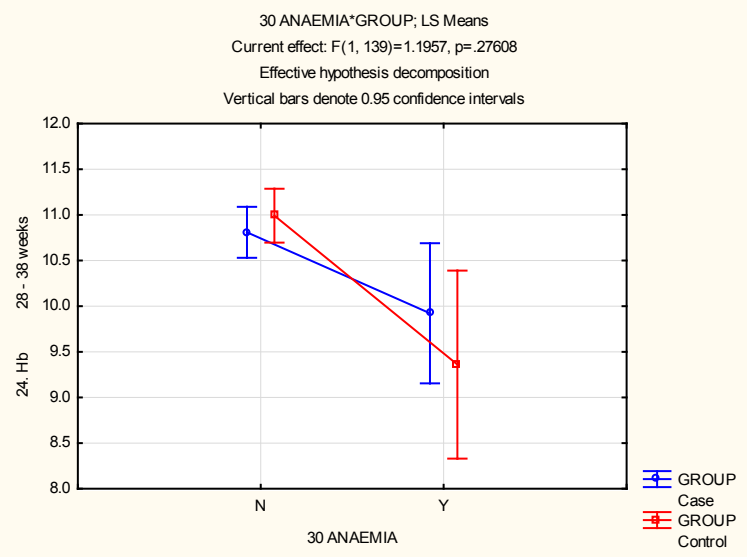

Figure 5.2: Bootstrap test of Hb values of both groups at 28 to 38 weeks versus anaemia

5.2.2.3 Hypothesis 3: Maternal tachycardia in late pregnancy is associated with adverse maternal and perinatal outcomes

This hypothesis was designed to determine an association between maternal tachycardia and specific adverse maternal outcomes as well as specific perinatal outcomes. Maternal outcomes were divided into maternal morbidity and maternal mortality. Perinatal outcomes were divided into birth weight, Apgar score, neonatal morbidity and neonatal mortality.

Table 5.2 displays a summary of the maternal morbidity that occurred in the case and the control group. As mentioned in section 4.2.6.4 the total maternal morbidity for the case group was higher (46.0% or n=43) when compared to the control group, which had only a total morbidity of 33.0% (n=32). Apart from haematological conditions the case group had a little more (3.0% or n=3) participants who had “other” complications, two percent more participants had anaemia and twice the frequency of infection. Referring to section 4.2.6.4 and table 4.19, the time difference between the Monica AN24™ recordings to the diagnosis of infection varied between two weeks, zero days and seven weeks, one day. The issue of time difference brings the validity of this finding into question – if maternal tachycardia has been present – could there have been a possible underlying infection, and if not, what was the reason for the tachycardia at the time? Further hypothesis testing was requested from the statistician to calculate whether there is a significant difference between infections in the case group versus the control group. A test for equality of proportions was done between the two groups that confirmed a p-value of 0.07 thus showing no significant difference between the groups of infection.

The incidence of maternal mortality was overall 1% in each group (n=1 case and n=1 control group). The cause of death for both participants was related to HIV. It is indeterminate to speculate that the population size will affect the increase in mortality incidence, as the numbers are very small.

The mean birth weight for the case group (3226g) exceeded the mean birth weight for the control group (3032g). The significant difference in mean birth weight indicates that the case group’s neonates generally weighed more. The fact that the gestational age did not differ significantly between the two groups, further supports the significance of the higher birth weight in the case group. There were no significant differences in the Apgar scores between the two groups.

The total neonatal morbidity in the case group accounted for 7.4% (n=7) and in the control group for 10% (n=10). These numbers indicates a higher prevalence of neonatal complications in the control group. There were two neonatal deaths in the control group and one in the case group. The neonatal death in the case group was due to transposition of the great arteries. One neonatal death in the control group was related to intrauterine growth restriction as caused by utero-placental insufficiency. The cause of the other infant death in the control group has not yet been classified. There were no intra-uterine deaths in either group. As the numbers were very small, once again, it would be premature to state that the difference between the two groups was significant or not.

After careful consideration of all the results mentioned above, the hypothesis that "maternal tachycardia in late pregnancy is associated with adverse maternal and perinatal outcomes" could not be accepted. Therefore this hypothesis was rejected.

Table 5.2: Summary of maternal morbidity in the two groups

Groups	30. Maternal morbidity Healthy	30. Maternal morbidity Infection	30. Maternal morbidity Anaemia	30. Maternal morbidity Other haematological conditions	30. Maternal morbidity Other	Total
Case	50 (54.0%)	17 (18.0%)	9 (10.0%)	3 (3.0%)	14 (15.0%)	93
Control	66 (67.0%)	9 (9.0%)	8 (8.0%)	3 (3.0%)	12 (12.0%)	98

5.3 LIMITATIONS OF THE STUDY

5.3.1 Lack of recording of vital signs, clinical findings and observations

The written information that was collected from the hospital notes and maternity case record booklets was habitually incomplete. This limited the actual data that was collected for this study. For example, the data of 51 participants of the Hb-value at 34 to 38 weeks was not available. However, as the differences in the mean Hb-values in this period was very small and did not differ significantly, it is unlikely that more available information would have changed the findings.

5.3.2 Lack of time

The limited time is believed to have been a shortfall in this study; therefore another study planned within a longer timeframe would be beneficial to collect more comprehensive data from a larger sample size in order to substantiate the study findings. Expanding the sample size means a far more accurate yield of statistics on women with cardiac disease.

5.4 RECOMMENDATIONS

5.4.1 Further research

On the basis of the above-mentioned limitation, this study should be seen as an introduction to a more extensive study in this field. Hence, further research is needed in this area of study. With the implementation of the new maternity case record booklet, it is important to evaluate the effectiveness it has on patient health.

5.4.2 Proper assessment of the respiratory and cardiovascular systems

Emphasis should be put on the importance of a complete physical examination of the maternal heart. Professional nurses and midwives doing the first encounter visit with a

pregnant woman must be competent enough to examine the respiratory and cardiovascular systems to be able to detect any abnormalities that exist or are arising.

None of the researcher's data reflects how well the examination of the maternal heart at the first antenatal visit was done and recorded. However, during the process of data collection, the researcher often noticed incomplete entries at the space on the maternity case record booklet where the entry of the examination of the heart should be entered. This places an uncertainty with the researcher to whether a proper examination of the heart and respiratory systems has been done in practice.

5.4.3 Generalising study findings

For future research in this field of study, a larger population and sample size can be selected in order to be able to generalise the findings of the study.

5.5 FINAL CONCLUSION

One of the outcomes of this study revealed that no pre-existing cardiac conditions were diagnosed in the population attending a government clinic in the Western Cape. Hence, this confirms that it is not necessary to record the maternal heart rate during every antenatal visit. Although the results from this study have highlighted a higher prevalence of infection in patients presenting with maternal tachycardia in late pregnancy, this difference was not significant between the two groups.

Even though there was no prevalence of cardiac disease and/or complications in this study, the researcher determined the prevalence of maternal tachycardia in a subpopulation of a study conducted in the Western Cape. To the researcher's knowledge, this is the first study known to examine the prevalence of maternal tachycardia in late pregnancy and the first to demonstrate that maternal tachycardia is associated with better fetal growth in uncomplicated cases.

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ADDENDA

ADDENDUM A: DATA COLLECTION INSTRUMENT

VARIABLE	Nr	PASS Pat ID	GROUP	Maternal age	Race	Gravidity	Parity	Pregnancy losses
DESCRIPTION			Case Control		B Black C Coloured W White O Other	1 2 3 4 5 6 and more	0 1 2 3 4 5 and more	AB1 Abortion 1 AB2 Abortion 2 MISC Miscarriage 1 MISC Miscarriage 2 NND Neonatal death ID Infant death IUD Intra-uterine death

6. Height	7. Weight	8. MHR Maternal	9. MHR Basal fetal	10. MHR Success rate	11. MHR Duration of recording	12. MHR Date of recording	13. Time last smoked	14. Time MHR recorded
		C Continuous **C100** Continuous (>100bpm all the time) **TB** Tachycardia at beginning, normal heart rate at end **TE** Tachycardia at end, normal heart rate at beginning **F100** Fluctuations to > 100bpm **F** Fluctuations **O** Other	**C** Continuous **C160** Continuous (> 160 bpm all the time) **TB** Tachycardia at beginning, normal heart rate at end **TE** Tachycardia at end, normal heart rate at beginning **F160** Fluctuations at above 160 bpm **F** Fluctuations **O** Other					

15. Number of ANC visits	16. Frequency of MHR recordings	17. MHRRA Booking	18. MHRRA Other ANC visits	19. MHRRA Walk-in visits	20. MHRRA Referrals	21. MHRRA Labour	22. MHRRA Post-delivery	23. Hb booking

24. Hb 28-38 weeks	25. Hb delivery	26. Hb frequency	27. Facility of delivery	28. Mode of delivery	29. Pre-existing conditions	30. Maternal morbidity	31. Maternal mortality
			MOU KBH TBH Other	N NVD C C/Section S Suction F Forceps VB Vaginal breech delivery	CA Coronary artery disease MI Myocardial infarction C Cardiomyopathy VHD Valvular heart disease CHD Congenital heart disease O Other H Healthy	A Anaemia CD Cardiac disease CC Cardiac complications I Infection HC Haematological cnditions O Other H Healthy	Y Yes N No

32. Neonatal gender	33. Neonatal morbidity	34. Neonatal mortality	35. Birth weight	36. GA at delivery days	37. GA at delivery weeks	38. SGA	39. Apgar 1 min	40. Apgar 5 min	41. Apgar 10 min
F Female M Male	RDS Respiratory distress syndrome I Infection NJ Neonatal jaundice O Other H Healthy	A Alive M Miscarriage I IUD N NND ID Infant death							

ADDENDUM B: ETHICAL APPROVAL

03 June 2011 **MAILED**

Prof HJ Odendaal
Department of Obstetric and Gynaecology
Tygerberg Hospital

Dear Prof Odendaal

"A prospective study on the role of prenatal alcohol exposure in sids and stillbirth."

ETHICS REFERENCE NO: N06/10/210

RE : AMENDMENT (MS N NEL)

"Prevalence of maternal tachycardia during late pregnancy "

Your letter received 13 May 2011 refers.

The Chairperson of the Health Research Ethics Committee approved the amended documentation in accordance with the authority given to him by the Committee.

The amendment was approved and a waiver of individual informed consent is granted.

Yours faithfully

MRS MERTRUDE DAVIDS
RESEARCH DEVELOPMENT AND SUPPORT
Tel: 021 938 9207 / E-mail: mertrude@sun.ac.za
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ADDENDUM C: WAIVER OF CONSENT

19 April 2010

Research Development and Support
For attention: Mrs Mertrude Davids
Tygerberg Campus

Dear Mrs Davids

ETHICS REFERENCE NO: N06/10/210

Main study: Title: *A prospective study on the role of prenatal alcohol exposure in SIDS and stillbirths.*

Sub study: Research proposal: Title: *Prevalence of maternal tachycardia during late pregnancy*

I refer to your letter of 22 October 2010 to Prof H J Odendaal. I hereby request a waiver of informed consent for this sub study for the following reasons:

- the study procedures of the sub study fall under the umbrella of the main study for which consent has already been obtained;
- the data has already been collected, and the researcher will be using data from the already collected data for a secondary data analysis; and
- the researcher will not include human participants, but only their data.

The proposal for the above sub study has been rewritten according to your recommendations.

Yours faithfully

The researcher,
Ms Nicola Nel
US nr: 14403609

ADDENDUM D: LANGUAGE EDITOR'S DECLARATION

Lize Vorster Communication

To whom it may concern

This letter serves as confirmation that I, Lize Vorster, have performed the language editing and technical formatting of Nicola Nel's thesis which entails ensuring its compliance with the Stellenbosch University's technical requirements.

Yours sincerely

Lize Vorster

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