VITAMIN D RELATED BEHAVIOURS AMONG PREGNANT WOMEN IN AUSTRALIA

Yue Wu

Paediatrician, MMed, BM

Submitted in fulfilment of the requirements for the degree of

Doctor of Philosophy

School of Public Health & Social Work

Faculty of Health

Institute of Health and Biomedical Innovation

Queensland University of Technology

October 2013

Keywords

Vitamin D, pregnant women, sun exposure, sun protection, dietary intake, supplement, pregnancy outcomes

Abstract

Maternal vitamin D deficiency during pregnancy has numerous health implications in both the mothers and their offspring, therefore, it is important to prevent women from vitamin D deficiency during this period. Even in Australia, with high levels of sunlight (which is the primary source of vitamin D in human beings), pregnant women have been reported to be at increased risk of vitamin D deficiency.

Because the determinants of vitamin D status are skin exposure to sunlight and oral intake of vitamin D from both foods and supplements, an individual's vitamin D status is affected by his or her sun exposure behaviours, such as time spent outdoors, clothing coverage and sunscreen use, as well as dietary behaviours. However, there is a lack of basic observational data on those sun exposure and dietary behaviours in pregnant women. In consideration of the high prevalence of vitamin D deficiency in pregnant women, and making effective strategies to prevent this issue, it is important to understand how pregnant women behave in regard to sun exposure and vitamin D intake.

This study aims to investigate these vitamin D related behaviours, including time outdoors, clothing, sunscreen use, dietary vitamin D intake and vitamin D supplement ingestion among pregnant women in Australia. One hundred and sixty-four pregnant women throughout Australia participated in web-based questionnaires with regard to their vitamin D related behaviours and the potential influencing factors, such as demographics, obstetrical variables, their knowledge and attitudes to vitamin D. Subsequently, 132 out of the whole 164 women completed a follow-up, online, pilot survey after their delivery to report their pregnancy outcomes, which aimed to explore the potential link between maternal vitamin D related behaviours during pregnancy and pregnancy outcomes.

The mean outdoor time for pregnant women in Australia was 52.46 (95% CI: 45.60 – 60.34) minutes per day(median: 60 minutes per day) on weekdays and was 89.12 (95% CI: 77.48 – 102.51) minutes per day (median: 90 minutes per day) on weekends. On average, 78% of their skin was covered by clothing whilst outdoors. Approximately half of the women applied sunscreen in the previous month.

The median dietary intake among these pregnant women was only 1.38 μg per day from foods. Of those who responded, 22.6% did not use of vitamin D supplements, whereas 12.8% reported consuming < 500 IU per day. Women living in a low ambient temperature or ultraviolet radiation environment covered their skin more with clothing, but were less likely to apply sunscreen. Women on ≥ 500 IU per day vitamin D supplements covered their skin more with clothing and tended to have less UV adjusted, outdoor time. No significant differences were found between maternal vitamin D related behaviours and pregnancy outcomes in the follow-up, pilot study.

In conclusion, pregnant women in Australia have low sun exposure and limited vitamin D intake, which may explain why pregnant women are prone to vitamin D deficiency in this country.

Main findings:

- Pregnant women in Australia get limited sun exposure.
- The intake of vitamin D from foods is low in Australian pregnant women who participated in this study.
- The application of vitamin-D-containing supplements in Australian pregnant women is greater than other populations in both proportion and amount, but for the majority of them, the intake amount still does not meet the current recommendations (15 μg per day).

Table of Contents

List of Tables

List of Figures

List of Abbreviations

1,25(OH)$_2$D	1,25-Dihydroxyvitamin D
25(OH)D	25-Hydroxvitamin D
7-DHC	7-Dehydroxycholesterol
AI	Adequate Intake
BMI	Body Mass Index
CRESH	Centre for Research Excellence in Sun and Health
FSANZ	Food Standards Australia and New Zealand
FGF-23	Fibroblast Growth Factor 23
G	Gram/s
GDM	Gestational Diabetes Mellitus
IOM	Institute of Medicine
IU	International Unit/s
KG	Kilogram/s
MS	Multiple Sclerosis
NHMRC	National Health and Medical Research Council
NMOL	Nanomole/s
PIS	Participant Information Sheet for QUT Research Project
PTH	Parathyroid Hormone
QUT	Queensland University of Technology
RA	Rheumatoid Arthritis
SGA	Small for Gestational Age
SLE	Systemic Lupus Erythematosus
SPF	Sun Protection Factor
UV	Ultraviolet
UVB	Ultraviolet B
UVR	Ultraviolet Radiation
VBD	Vitamin D Binding Protein
VDR	Vitamin D Receptor
µg	Microgram
USA	United States of America
WHO	World Health Organization

Conversions for vitamin D:

[Sources] 40 IU = 1 µg

[Serum] 2.5 nmol/L = 1 ng/mL

Statement of Original Authorship

The work contained in this thesis has not been previously submitted to meet requirements for an award at this or any other higher education institution. To the best of my knowledge and belief, the thesis contains no material previously published or written by another person except where due reference is made.

Signature: Yue Wu

Date: 22/09/2013

Acknowledgements

This work would not have been successfully completed without the support of many people. My special thanks go to my principal supervisor, Professor Michael Kimlin. His utmost patience in reading through my proposal, his encouragement and support right from proposal development to the final thesis requires special mention. Sincere gratitude is also extended to my associate supervisors, Professor David Kavanagh and Dr. Jiandong Sun, as well as my external supervisors, Professor John McGrath from the University of Queensland and Associate Professor Robyn Lucas from the Australian National University, for their tireless efforts in moulding my proposal until the end.

I am very grateful to the China Scholarship Council and Queensland University of Technology, which provided finances for this research work of 36 months and six months respectively. I thank them so much because, without their kind consideration, this research would not have been easy for me. Their investment in this study has not only enabled me complete this requirement in my academic pursuits, but also to contribute to the knowledge of management of vitamin D deficiency during pregnancy and, ultimately, to promote the health of women and children.

I am greatly indebted to all of the members at AusSun Research Lab for valued advice and support along the way, giving me the confidence to pursue this academic challenge. Your kindness will never be forgotten.

I express special thanks to my family for their love and unceasing support. Without them, this course would not have been completed. I have not been a good daughter, wife and mother for removing myself greatly away from your lives in the past couple of years, but, hopefully, I can do better after my return.

Last but not least, I deeply appreciate all of the participants in this study, for their altruistic and invaluable contribution. Their generous time and energy input encouraged me to devote myself to this research.

Chapter 1: Introduction

This chapter provides an overview of background issues relevant to this thesis and includes a brief description of the rationale for undertaking the research. It is followed by a description of the study aim, objectives and research questions. The significance of this research will also be discussed. Finally, an outline of the remaining chapters of the thesis will be presented.

1.1 BACKGROUND AND RATIONALE FOR THE STUDY

1.1.1 Background

Vitamin D is a fat-soluble vitamin which includes both animal-derived cholecalciferol (vitamin D_3) and plant-derived ergocalciferol (vitamin D_2) (Holick, 2006). There are two ways for people to get vitamin D, produced in the skin by exposure to UVB, and from diet and/or supplements (Holick, 2008). Vitamin D coming from the skin or from the diet/supplements enters the circulation, and undergoes two sequential hydroxylation for activation (Holick, 2006). First in the liver, vitamin D is converted to 25(OH)D (White, 2008). Then 25(OH)D is hydroxylated to its active form $1,25(OH)_2D$ in the kidney or other extrarenal sites (Bikle, 2009). The active form of vitamin D, $1,25(OH)_2D$, works through binding to a nuclear receptor (Vitamin D Receptor, VDR) that results in a conformational change in the VDR, which allows it to interact with specific DNA sequences, vitamin D response elements, on target genes to activate or repress gene transcription to engender its biological actions (White, 2008).

For decades, vitamin D is seen as “the bone vitamin” because of its major function, also called the classic function is in controlling calcium and bone homeostasis (M. F. Holick, 2005; Michael F. Holick & Chen, 2008; Millen & Bodnar, 2008). Severe vitamin D deficiency causes rickets in children (Ward et al., 2007), or osteomalacia in adults and possibly contributes to osteoporosis (Adams et al., 1999). Additionally, in the last few years, many other so-called nonclassic functions of vitamin D have been identified and through these mechanisms vitamin D insufficiency has been linked to an increased risk of a large number of diseases. $1,25(OH)_2D$ has been shown to be capable of regulating cell differentiation and proliferation, as well as regulating immune function and hormone secretion (Bikle, 2009). Associated health problems are thought to include cardiovascular disease (Pilz et al., 2008), immune disorders (Cutolo & Otsa, 2008), and several cancers (Garland et al., 2009), demonstrating a breadth of possible effects of vitamin D on human health.

During pregnancy, it is more critical to ensure vitamin D adequacy for the health of both mother and offspring. Vitamin D deficiency during pregnancy has been associated with increased risk for negative pregnancy outcomes, including preeclampsia, gestational diabetes mellitus, primary caesarean section, vaginosis, lower birth weight, reduced infant size and impaired bone development (Thorne-Lyman & Fawzi, 2012; Wagner et al., 2012).

Individuals achieving and maintaining adequate vitamin D levels becomes exclusively essential for its important role in human health. Surprisingly, vitamin D deficiency is worldwide spread among general populations. Studies carried across different countries in Asia showed widespread prevalence of hypovitaminsis D in different populations (Arya et al., 2004; Lim et al., 2008; Yan et al., 2000). In Europe, vitamin D deficiency is more common in Southern than in Northern regions due to higher consumption of fatty fish and cod liver oil in the latter compared to the former (Brustad et al., 2004). In the USA, serum 25(OH)D levels have been assessed in a representative sample of 20 289, males and females in the National Health and Nutrition Examination Survey over the period of 2002-2004, the data indicate vitamin D status is low in many groups (Looker et al., 2008). Despite ample sunshine, the Middle East and Africa register the highest rates of rickets worldwide, possibly because of limited sun exposure due to local culture in the Middle East (Baroncelli et al., 2008), and dark skin (thus less efficient synthesis of vitamin D) in Africa (Pettifor, 2004). Notably, vitamin D deficiency has also re-emerged as a significant health issue in Australia and New Zealand despite these countries' high levels of ambient UV radiation and high level of sun exposure.

The situation of vitamin D deficiency is even worse in pregnant women over the world. Table 1.1 lists the worldwide prevalence of vitamin D deficiency during pregnancy. A cut-off point of 25-hydroxvitamin D (25(OH)D) < 50 nmol/L is applied to define vitamin D deficiency, based on the latest guidelines by the Institute of Medicine (IOM), USA, in 2010 (Ross et al., 2011). The prevalence ranges from 23% to up to 90% and it occurs at any stage of gestation. Even in Australia, with plenty of sunshine over the whole year, which, for most people, is the primary source of vitamin D, vitamin D deficiency during pregnancy is still a problem. The details are in Table 1.2.

Table 1.1 Worldwide prevalence of vitamin D deficiency during pregnancy

Country of study	Year of study or published	Gestational weeks	Prevalence (n/N)	Reference
USA	2010	First trimester	33% (102/309)	Ginde *et al.*
Canada	2011	12-18	39% (272/697)	Wei *et al.*
UK	2011	First trimester	57% (90/158)	Makgoba *et al.*
Spain	2011	24-28	59% (157/266)	Perez-Ferre *et al.*
Denmark	2010	39	23% (32/141)	Milman *et al.*
Finland	2011	First trimester	70% (481/686)	Miettinen *et al.*
Turkey	2008	$\geqslant 37$	90% (233/258)	Halicioglu *et al.*
United Arab Emirates	2007	At delivery	78% (21/78)	Narchi *et al.*
Japan	2008	> 30	90% (83/93)	Shibata *et al.*

Note: Definition of vitamin D deficiency: 25(OH)D< 50 nmol/L

Table 1.2 Australia nationwide prevalence of vitamin D deficiency during pregnancy

Site of study	Year of study or published	Gestational weeks	Prevalence (n/N)	Reference
Sydney	2009	30-32	48% (466/971)	Bowyer *et al.*
Rural Victoria	2010	Around 28	25.8% (85/330)	Teale *et al.*
Canberra	2010	14-28	31% (31/100)	Perampalam *et al.*
Campbelltown	2010	14-28	20.8% (21/101)	Perampalam *et al.*

Note: Definition of vitamin D deficiency: 25(OH)D< 50 nmol/L

The determinants of vitamin D status are skin exposure to sunlight and intake of vitamin D, either from foods or supplements (Holick, 2007). Therefore, individual vitamin D status is affected by his/her sun exposure behaviours, such as outdoor time, clothing and sunscreen use, and dietary behaviour.

With sufficient sun exposure, a healthy person should be able to produce adequate vitamin D to meet the body's requirement (Holick, 2011). In light of the sunny climate in Australia and general propensity for outdoor activities, it has long been assumed that vitamin D deficiency would be rare in Australian adults. In addition, Australia has the highest incidence of skin cancer in the world due to extreme levels of ambient UV radiation (Staples et al., 2006). For the general population, the major concern in Australia is *overexposure* to sunlight rather than *underexposure*(Stanton *et al.*, 2004). Since the early 1980s, Australian government media campaigns have highlighted the harm of sun exposure with the use of "slip, slop, slap" advertising to urge the population to avoid sun exposure (Montague *et al.*, 2001). However, such strict sun avoidance at the same time induces the risk of vitamin D deficiency nationwide (van der Mei *et al.*, 2007). Unavoidably, there is some controversy about the need to minimize the risk of skin cancer while optimizing vitamin D synthesis from sun exposure. Currently, there is a lack of validated safe threshold level of sun exposure that allows for maximal vitamin D synthesis without increasing the skin cancer risk. It may be that no such 'optimal range' exists, and that the public health community is faced with the vexing issue of 'competing risks' (avoiding one type of harmful exposure may increase the risk of a different adverse health outcome). Meanwhile, sensible sun exposure depends on a range of factors, including location, season, time of the day, individual characteristics such as skin colour, age, etc., which makes it difficult to make simple and readily marketable recommendations for sun exposure. In light of the particularity of pregnancy, extreme caution should be exercised when given sun exposure recommendations. However, there is lack of basic observational data on those sun exposure behaviours in pregnant women, let alone a suitable recommendation of sun exposure for them.

Foods and vitamin D supplements have the advantage of not causing skin cancer and other unwanted effects on the skin that can be caused by sun exposure (Nowson & Margerison, 2002). Meanwhile, a current indoor lifestyle also leads people out of the sun (Holick, 2005). Under such circumstances, vitamin D intake may be more important to our serum vitamin D concentration. Several clinical trials have been conducted, indicating there are mechanisms to reduce vitamin D deficiency in pregnancy by dietary interventions (Brooke et al., 1980; Delvin et al., 1986; Hollis et al., 2011; Mallet et al., 1986; Marya et al., 1988; Yu et al., 2009). In addition, a few observational studies in several countries have also been conducted, evaluating vitamin D intake from foods and/or supplements in pregnant women (Table 1.3). However, there is lack of such basic observational data on vitamin D intake from foods and supplements in pregnant women in Australia.

Table 1.3 Observational studies of vitamin D intake from foods and supplements in pregnant women

Reference	**Country of study**	**Population**	**Vitamin D intake (IU/day)**	**Outcomes**
Li *et al.*, 2011	Canada (Vancouver, 49ºN)	336 pregnant women with diverse ethnicity, at 20–35 weeks of gestation	200 from foods 400 from supplements	Mean 25(OH)D was 76 nmol/L, 24% < 50nmol/L.
Scholl *et al.*, 2009	USA (Camden, New Jersey, 39ºN)	2,251 low income, minority pregnant women, at 20–28 weeks of gestation	192 from foods 220 from supplements	No measure of serum 25(OH)D, but total vitamin D intake was associated with increased infant birth weight.
Camargo *et al.*, 2007	USA (Massachusetts, 42ºN)	1,194 mid-class mother-child pairs, after initial clinical prenatal visit	225 from foods 319 from supplements	No measure of serum 25(OH)D. A 100-IU increase in vitamin D intake of mother in pregnancy was associated with lower risk of recurrent wheeze in child.
Haugen *et al.,* 2009	Norway (nationwide, 58º - 71ºN)	23,423 nulliparous pregnant women taking part in the Norwegian Mother and Child Cohort Study	Women with preeclampsia: 120 from foods, 176 from supplements; Women without preeclampsia: 120 from foods, 200 from supplements	No measure of serum 25(OH)D. Total vitamin D intake: 72.6% < 600 IU/day. A 27% reduction in risk of preeclampsia for women taking 400–600 IU/day vitamin D supplements compared with no supplements.
Vilijakainen et al, 2010	Finland (Helsinki, 60ºN)	125 primiparous pregnant women who were healthy, non-smoking, of Caucasian origin	312 from foods 80% women used supplements with 264 on average	77.4% had 25(OH)D levels < 50 nmol/L at first trimester, 60.4% postpartum.
Jensen *et al.*., 2012	Denmark (nationwide, 55º - 57º N)	68,447 Danish pregnant women from Danish National Birth Cohort, 21-25 weeks of gestation	142.4 from foods 226.8 from supplements	32.5% didnot take vitamin D supplements. Total vitamin D intake was 369.2 IU/day.

1.1.2 Rationale for this Study

From the prior section, it is clear that vitamin D deficiency during pregnancy is common throughout the world, including Australia, a country with a temperate climate and ample sunlight year-around. Low maternal vitamin D status during pregnancy has been associated with numerous adverse health outcomes in both mother and offspring with short-term and/or long-term effects. Women are already aware of the need for optimal folate and iron supplementation related to pregnancy (Imdad & Bhutta, 2012); it remains to be seen how aware they are of the need to optimize their vitamin D status. However, basic observational data about pregnant women's sun exposure behaviours and vitamin D intake, which may affect their vitamin D status, are limited, especially in Australia. Additionally, the epidemiological evidence about recommendations for pregnant women is incomplete. In consideration of the high prevalence of vitamin D deficiency in pregnant women, and making effective strategies to prevent this issue, it is important to understand how pregnant women behave in regard to sun exposure and vitamin D intake. In order to explore this research question, this study was undertaken to evaluate pregnant women's vitamin D related behaviours, including sun exposure and protective behaviours, dietary vitamin D intake and vitamin D supplement ingestion during pregnancy in Australia. Also, since vitamin D status has been linked to pregnancy outcomes, a follow-up, sub-pilot study was conducted to investigate the direct relationships between these behaviours and pregnancy outcomes.

As this thesis has a focus on a public health perspective, the focus would have been on behaviours that influence vitamin D concentrations, however, due to the difficulty in collecting blood samples throughout Australia and a limited budget, it is important to note that serum 25(OH)D was not measured in the women participating in the study. Instead, participants were asked whether they had undertaken this test during their pregnancy, and the result was requested of those who were able to provide it.

1.2 RESEARCH AIM, OBJECTIVES AND RESEARCH QUESTIONS

The overall aim of this project was to describe how women in Australia behave in relation to sun exposure and vitamin D intake during pregnancy.

The specific **objectives** of this research were to:

- describe the current behaviours in relation to vitamin D production among pregnant women in Australia, including sun exposure and sun protective behaviours (outdoor time, clothing and sunscreen use), dietary intake of vitamin D and vitamin D supplement ingestion;
- examine influencing factors on these behaviours, including demographics, obstetrical variables, knowledge of and attitudes to sun and vitamin D;
- explore the relationships between maternal vitamin D related behaviours during pregnancy and pregnancy outcomes.

The **research questions** were:

- How do pregnant women in Australia behave in terms of sun exposure and protection (outdoor time, clothing and sunscreen use)?
- What factors have an effect on these sun exposure and protective behaviours?
- What is the level of vitamin D intake from foods and supplements among pregnant women in Australia?
- What are the influencing factors for vitamin D intake from foods and supplements?
- What are the relationships between these behaviours?
- Are these maternal vitamin D related behaviours during pregnancy associated with pregnancy outcomes?

1.3 SIGNIFICANCE

This study will contribute to the expanding body of knowledge related to vitamin D deficiency management in pregnancy. It is believed that this is the first study systemically evaluating pregnant women's vitamin D related behaviours in Australia. This study complements current understanding of the links between vitamin D and pregnancy related outcomes. In light of existing evidence, public health intervention to decrease the prevalence of vitamin D deficiency in pregnant women in Australia is needed. The identification of behavioural factors associated with vitamin D status in pregnant women is an important first step in future programs of public health research aimed at reducing the prevalence of vitamin D deficiency in this vulnerable population.

This study also allows for the prediction of certain vitamin D related behaviours in pregnant women across different demographic or obstetrical characteristics, by which those pregnant women, who are at relatively higher risk of vitamin D deficiency, could possibly be identified for screening and early treatment.

1.4 THESIS OUTLINE

Chapter Two provides a literature review of vitamin D fundamental information and vitamin D in pregnancy. Chapter Three details the research design, including methodology, sampling, recruitment, survey administration, data collection, data analysis and ethics, which help to achieve the aim and objectives described herein. Results are presented in Chapter Four, followed by a detailed discussion of the results in Chapter Five. Finally, Chapter Six provides a conclusion of the key findings from the research, including acknowledgement of strengths and limitations of the study.

Chapter 2: Literature Review

2.1 INTRODUCTION

Vitamin D is known as a sunshine vitamin, which is produced in the skin by exposure to ultraviolet B radiation, and with a small portion from diet and/or supplements (Holick, 2008). The role of vitamin D in bone health has long been well established, with vitamin D deficiency being a causal factor in the development of rickets in children, osteomalacia in adults, and contributing to osteoporosis (Schwalfenberg, 2007). Data are also suggestive of a potential role of vitamin D in other, non-bone related health conditions. Low vitamin D status has been associated with a wider range of adverse health outcomes, including cardiovascular disease (Pilz et al., 2008), diabetes (Choi et al., 2011), cancer (Orell–Kotikangas et al., 2012) and psychiatric disorders (Wilkins, Sheline, Roe, Birge, & Morris, 2006). Vitamin D deficiency now has become a major public health concern because it is widespread over the world, even in sunny countries (Mithal et al., 2009).

During pregnancy, a woman maintains her vitamin D requirements to support her own health, but also needs the extra amount to support her fetus. Thus, achieving and maintaining adequate vitamin D is much more critical in pregnant women than in any other population (Kovacs, 2008). There is increasing evidence showing that vitamin D status during pregnancy is integral to maternal health, fetal development, and optimal neonatal outcomes as well as future health of the offspring (Camadoo et al., 2007; Lucas et al., 2008; Mahon et al., 2009; Zhang et al., 2008). However, numerous observational studies have also discovered an epidemic of vitamin D deficiency in pregnant women over the world regardless their ethnicity and region (Kazemi et al., 2009; Sachan et al., 2005; van der Mei et al., 2007).

The present review unfolds recent developments in vitamin D synthesis, metabolism, and functions, and then focuses on the role of vitamin D during pregnancy.

2.2 BACKGROUND OF VITAMIN D

2.2.1 Sources of Vitamin D

Vitamin D is a fat-soluble vitamin that includes both cholecalciferol (vitamin D_3) and ergocalciferol (vitamin D_2) (Holick, 2006). 'Vitamin D' hereafter refers to both vitamin D_3 and D_2. Human beings obtain vitamin D through two ways: endogenous and exogenous sources (Alpert & Shaikh, 2007).

For most people, vitamin D is largely endogenouslyderived through cutaneous synthesis of vitamin D_3 following exposure of the skin to sunlight (Holick, 2004). Solar, ultraviolet B radiation (UVB, wavelength 290 to 315 nm), one of the components of sunlight, penetrates the skin and converts 7-dehydrochlesterol (7-DHC) (also called provitamin D) to previtamin D_3, which is quickly converted to vitamin D_3 thermally (Norman & Powell, 2005). Excessive exposure to sunlight does not cause vitamin D_3 intoxication, because sunlight destroys any excessive previtamin D_3 or vitamin D_3 by converting it intoinactive photoproducts (Holick, 2007). Additionally, vitamin D_3 is fat-soluble and excess amounts can be taken up by adipocytes and stored in adipose tissue (Dusso *et al*., 2005).

Exogenous sources of vitamin D include foods naturally rich in vitamin D, vitamin D fortified foods and vitamin D supplements. The dietary intake is more important when sun exposure is limited. Vitamin D_3 is found naturally in only a few foods (Raiten & Picciano, 2004), including oily fish, such as salmon, mackerel and herring, and fish liver oil due to majority fat concentrates in liver, with even smaller quantities available in egg yolks and meat (Jasinghe et al., 2005). Plant sources of vitamin D are in the form of vitamin D_2, which is produced through the ultraviolet irradiation of ergosterol from yeast and mushrooms (Holick, 2005). Currently, vitamin D fortified foods are available in many countries, however, the fortification policies vary widely among countries. In Australia, foods like margarine and edible oil spreads are currently mandatedto be fortified with vitamin D, whilst some milk and milk products are voluntarily fortified (Stroud *et al*., 2008). Apart from these sources above, oral vitamin D supplements in different doses are widely available over-the-counter in most countries (Bischoff-Ferrari, 2009) and probably offer the most effective, alternative way for those people who are unable to obtain adequate amounts of vitamin D from sun exposure or food sources.

2.2.2 Metabolism of Vitamin D

Vitamin D, coming from actinic production or diet, enters the blood circulation where it is bound to the vitamin D binding protein (DBP), a major serum carrier protein for vitamin D and its metabolites with high affinity, which transports it to the liver and kidneys to undergo two sequential hydroxylation (Holick, 2006).

The first step in the metabolic activation of vitamin D is hydroxylation of carbon 25 by vitamin D-25-hydroxylase, which converts vitamin D to 25-hydroxyvitamin D [25(OH)D] in the liver (White, 2008). 25(OH)D is the major circulating form of vitamin D and the usual measure of vitamin D status for individuals (Seamans & Cashman, 2009).

The second hydroxylation is mediated by 25-hydroxyvitamin D-1α-hydroxylase to the biologically active form, 1,25-dihydroxyvitamin D [1,25$(OH)_2$D].This mainly in the kidneys(Dusso et al., 2005). Recently, studies have found that 1-α-hydroxylation may also occur in many other extrarenal sites including the breasts, lungs, placenta, colon, osteoblasts and activated macrophages. This finding indicates an autocrine-paracrine role for 1,25$(OH)_2$D (Bikle, 2009). 25-hydroxyvitamin D-24-hydroxylase,which is a multicatalytic enzyme, catabolizes both 25(OH)D and 1,25$(OH)_2$D to the water-soluble, biologically inactive, calcitroic acid, which is then excreted in urine (Anderson *et al*., 2003). Figure 2.1 depicts the vitamin D pathway(Tsiaras & Weinstock, 2011).

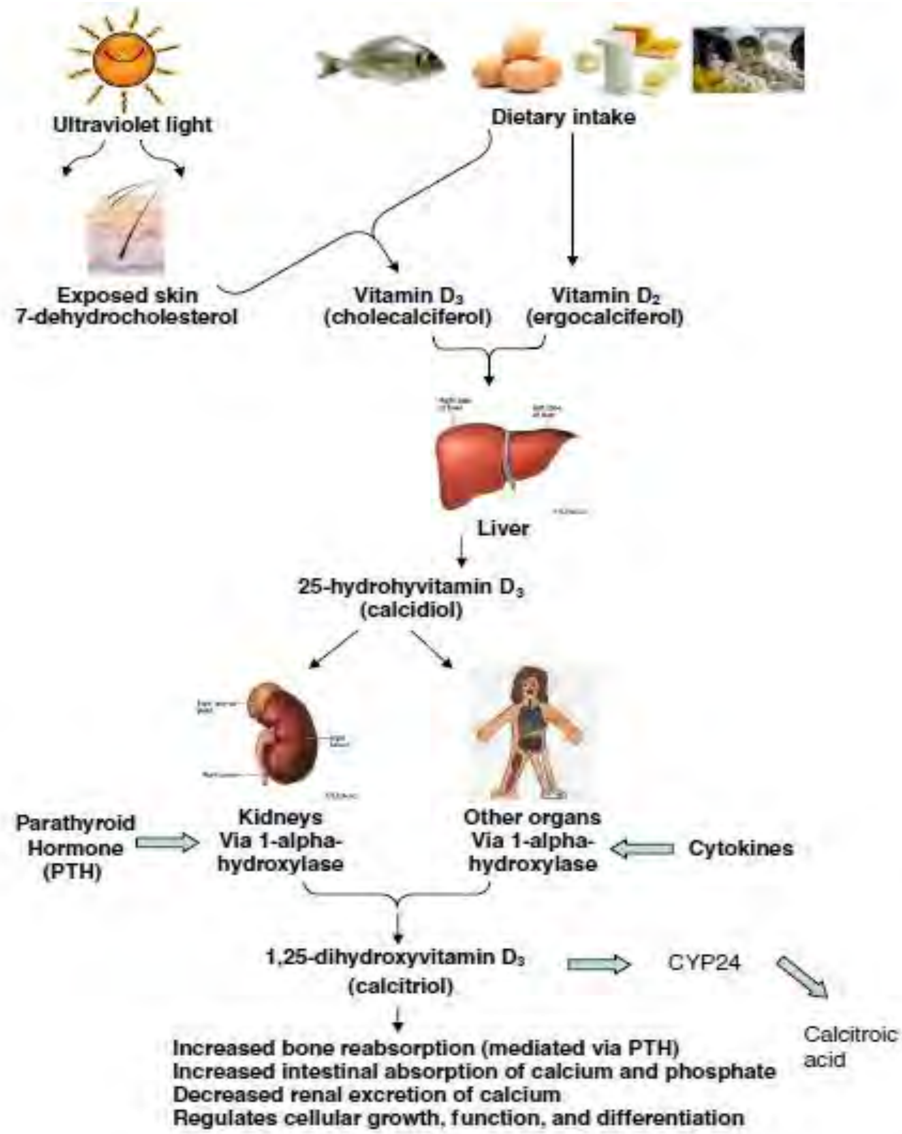


Figure 2.1 Pathway of vitamin D synthesis and metabolism

2.2.3 Assessment of Vitamin D Status

The measurement of the major circulating form of vitamin D, 25(OH)D, is the gold standard for determining individual vitamin D status currently (Zerwekh, 2008). As previously noted, serum 25(OH)D reflects vitamin D inputs both from cutaneous synthesis and dietary intake. Although $1,25(OH)_2D$ is the active form of vitamin D, it is not used for determining vitamin D status. The reasons are as follows: Firstly, the half-life of 25(OH)D is two to three weeks, much longer than that of $1,25(OH)_2D$, which has a half-life of only about four hours. Secondly, $1,25(OH)_2D$ is usually normal or even elevated in patients with vitamin D deficiency (Prentice *et al.*, 2008). Thirdly, the concentration of $1,25(OH)_2D$ is at picomolar levels, 100- to 1,000-fold less abundant than 25(OH)D in the blood circulation. It is more difficult to be detected, therefore, 1,25$(OH)_2$D concentration does not reflect long-term vitamin D status. Furthermore, low 25(OH)D has been linked with classic conditions of vitamin D deficiency, such as hypocalcemia and secondary hyperparathyroidism. Likewise, an increasing 25(OH)D level has been correlated with recovery from these conditions (Holick, 2003). Testing of serum 25(OH)D is most useful in patients who are at risk of vitamin D deficiency, including elderly patients, children with rickets and adults with osteoporosis. This measurement is also useful for purposes of planning or monitoring vitamin D therapy.

2.2.4 Classification of Vitamin D Status

Partly due to differences in 25(OH)D measurement techniques and the variability of vitamin D levels in the human body, there is a lack of consensus on the cut-off points that denote different vitamin D status categories. The conservatively used cut-off points in the last decade are:

- vitamin D deficiency, 25(OH)D < 25nmol/L, which implicates that, below this level, adverse effects like rickets and osteomalacia are observed in children and adults;
- vitamin D insufficiency, 25(OH)D of 25-50nmol/L, between this range increased bone resorption and elevated risk for secondary hyperparathyroidism are seen; and
- adequate status, 25(OH)D > 50nmol/L (Newson & Margerison, 2002; van der Mei et al., 2007).

In 2008, a review by vitamin D expert, Professor Michael Holick (Holick & Chen, 2008), reported slightly different guidelines:

- vitamin D deficiency, 25(OH)D < 50nmol/L (20ng/mL);
- vitamin D insufficiency, 25(OH)D 51–74nmol/L(21–29ng/mL);
- vitamin D sufficiency, 25(OH)D >75nmol/L (30ng/mL); and
- vitamin D toxicity, 25(OH)D > 375nmol/L(150ng/mL).

As the suppression of parathyroid hormone (PTH) is seen as beneficial for bone, serum 25(OH)D concentrations >75nmol/L are seen as desirable, as this is the concentration at which PTH approaches a minimum level and intestinal calcium absorption is maximal (Heaney, 2000). Notably, recent evidence suggests that the optimal concentration of 25(OH)D may be even higher, at least 80nmol/L, with regard to the potential role of vitamin D in non-bone health conditions (Hollis, 2005). The latest recommendations from the Institute of Medicine (IOM) of the United States of Americaadvise that a serum 25(OH)D level of 50nmol/L(20ng/mL) would cover the requirements of 97.5% of the population, even under conditions of minimal sun exposure (Ross et al., 2011), therefore, it supports < 50 nmol/L as vitamin D deficiency. However, this issue is still the subject of some debate and needs further robust evidence.

2.2.5 Function of Vitamin D

The action of 1,25$(OH)_2$D, whether formed in the kidneys or extra-renal sites, is mediated by its binding to a nuclear receptor (Vitamin D Receptor, VDR). Once the two combine together, which results in a conformational change in the VDR, allowing it to interact with specific DNA sequences, called vitamin D response elements (VDREs), on target genes to activate or repress gene transcription to engender biological actions of 1,25$(OH)_2$D (White, 2008). VDR is widely, although not universally, distributed throughout the different tissues of the human body (John *et al.*, 2007), which indicates a wide range of biological functions of vitamin D. Generally, the functions are categorized into two parts of general effects. Firstly, 1,25$(OH)_2$D plays its classic role, including regulation of serum calcium and phosphate levels by actions at intestine, bone, parathyroid and kidney (Holick, 2005). Secondly, the non-classic roles in regulating hormone secretion, regulating cellular proliferation and differentiation, and modulating immune response at other sites, such asthe skin, breasts, prostate and immune system, being associated with many diseases (Holick, 2008). The functions of vitamin D are summarized in Figure 2.2 below.

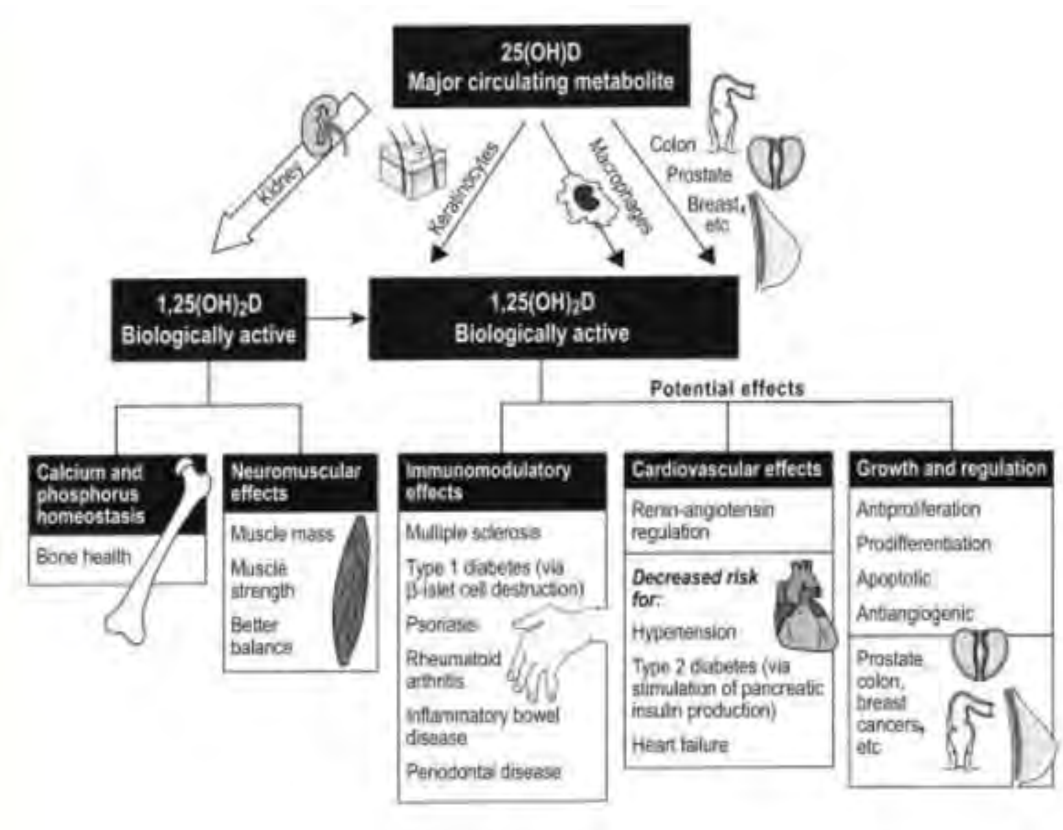


Figure 2.2 Functions of vitamin D, adapted from(Holick, 2006)

The major function, also called the classic function of 1,25$(OH)_2$D is in controlling calcium and bone homeostasis (Holick, 2005; Holick & Chen, 2008; Millen & Bodnar, 2008). Under the influence of 1,25$(OH)_2$D, the efficiency of intestinal calcium absorption is increased to 30-40%, whilst otherwise, less than 15% of dietary calcium is absorbed by human (DeLuca, 2004; Heaney et al., 2003). Vitamin D deficiency results in a low ionized calcium level, which stimulates secretion of PTH, leading to hyperparathyroidism. Hyperparathyroidism increases intestinal calcium absorption, mobilizes calcium from bone, and causes renal calcium conservation but increases excretion of phosphate. As a result, in vitamin D deficiency the serum calcium concentration may be normal, but bone mineralization is impaired (Misra et al., 2008). Severe vitamin D deficiency causes rickets in children (Ward et al., 2007), or osteomalacia in adults and possibly contributes to osteoporosis (Adams et al., 1999). In addition, vitamin D adequacy is important to muscle performance and through this mechanism may reduce the risk of falling in elderly people (Janssen, Samson, & Verhaar, 2002). Severe vitamin D deficiency is associated with muscle weakness (Venning, 2005) and limb pain (Kessenich, 2010).

In addition to this classic function, in the last few years, many other so-called non-classic functions of vitamin D have been identified. Basically, these functions can be classified into three categories as mentioned above, regulation of hormone secretion, regulation cellular proliferation and differentiation, and modulation of immune function (Holick, 2008). In accordance with these functions, vitamin D insufficiency has been linked to an increased risk of a large number of diseases. Associated health problems are thought to include cardiovascular disease (Pilz et al., 2008), immune disorders (Cutolo & Otsa, 2008) and several cancers (Garland *et al.*, 2009). For example, in a prospective study, 714 community-dwelling women (aged 70 to 79 years) were followed up within a median of 72 months. 14% of women died in that period, among whom women with serum 25(OH)D levels < 38.2 nmol/L were at higher risk of all-cause death (HR: 2.45; 95% CI, 1.12-5.36; $P = 0.02$) compared to women with serum 25(OH)D levels > 67.4 nmol/L (Semba et al., 2009). Another study found that individuals with 25(OH)D <37.5nmol/L were more likely to develop cardiovascular events, compared with those with 25(OH)D ≥37.5 nmol/L (HR: 1.62, 95% CI: 1.11, 2.36, P=0.01) (Wang *et al.*, 2008). A case-control study examining the association between pre-diagnostic serum 25(OH)D concentration and the risk of colorectal cancer in European populations also showed a strong, inverse, linear, dose-response association between levels of pre-diagnostic 25(OH)D concentration and risk of colorectal cancer (Jenab et al., 2010). One small, cross-sectional study investigating vitamin D status and insulin requirements in children with type Ⅰ diabetes found that the insulin requirement of patients with 25OHD <10 ng/mL were significantly higher than those of patients with 25OHD >10 ng/mL (p = 0.012) (Thnc *et al.*, 2011). Besides the diseases discussed above, other diseases, such as type Ⅱ diabetes (Mitri, Muraru, & Pittas, 2011), infectious disease (Vescini et al., 2011) and allergic disease (Carroll et al., 2011) have also been addressed an association with vitamin D.

In summary, vitamin D does play an important role in human health other than bone health, making researchers keep their enthusiasm in discovering the myraid of vitamin D.

2.2.6 Epidemiology of Vitamin D Deficiency

As demonstrated above, vitamin D plays an important role in human health, thus, individuals achieving and maintaining adequate vitamin D becomes exclusively essential. Vitamin D status has been investigated in most countries around the world; however, findings are not optimistic. Studies carried out across different countries in Asia showed a widespread prevalence of low vitamin D status in different populations (Arya et al., 2004; Lim et al., 2008; Yan et al., 2000). Paradoxically, in Europe, vitamin D deficiency is more common in southern than in northern regions, due to higher consumption of fatty fish and cod liver oil in the latter compared to the former (Brustad*et al.*, 2004). In the USA, serum 25(OH)D levels have been assessed in a representative sample of 20,289 males and females in the National Health and Nutrition Examination Survey over the period 2002 to 2004. The resulting data indicated that the vitamin D status is low in many groups (Looker*et al.*, 2008). Despite ample sunshine, the Middle East and Africa register the highest rates of rickets worldwide, possibly because of limited sun exposure, due to local culture in the Middle East (Baroncelli*et al.*, 2008), and dark skin (thus less efficient synthesis of vitamin D) in Africa (Pettifor, 2004). Notably, vitamin D deficiency has also re-emerged as a significant health issue in Australia and New Zealand despite these countries' high levels of ambient UV radiation and high levels of sun exposure year round (Erbas*et al.*, 2008; Grant *et al.*, 2009).

2.2.7 Causes of Vitamin D Deficiency

There are a variety of factors attributing to low serum vitamin D levels in individuals, from living environment and lifestyle to physical characteristics. See Figure 2.3.

2.2.7.1 Low ambient, ultraviolet radiation levels

People are more likely to have a low vitamin D status when living at higher latitude, because little vitamin D_3 is produced in the skin. The reason is a decrease in incident ultraviolet radiation with increasing latitude (Diamond, 2005). Similarly, in the winter season, UVB photons need to pass through a greater distance of atmosphere, therefore, fewer photons reach the earth. It is reported that at, above 37° north latitude in the winter months, the number of UVB photons reaching the Earth's atmosphere is decreased by 80% to 100% (Holick, 2004). Cloud cover and industrial pollution also reduce the amount of UVB irradiation that reaches the Earth's surface (Agarwal et al., 2002).

2.2.7.2 Limited sun exposure

The time spent outdoors is an important factor in determining individual exposure to sunlight, thus, any reason that keeps people spending more time indoors leads to decreased vitamin D synthesis through sun exposure. As mentioned earlier, vitamin D is made by our skin when it is exposed to sunlight, so, the amount of skin exposed to the sun is important to vitamin D synthesis.If too much of the body is covered by clothing, UVR and, thus, vitamin D synthesis, is reduced (Alagöl et al., 2000). A sunscreen with a sun protection factor (SPF) 15 (applied correctly) can decrease the ultraviolet dose to relevant skin structures by 98% (Matsuoka *et al.*, 1987). Furthermore, shade can reduce the amount of solar radiation hitting the skin by 60%, and windowpanes also block UV radiation(Holick, 1995).

2.2.7.3 Inadequate vitamin D intake

Limited intake of foods rich in vitamin D, low intake of fortified foods and no use of supplements may result in vitamin D deficiency in populations (Lamberg-Allardt *et al.*, 1993). Exclusively breastfed infants are prone to being vitamin D deficient, because human milk is a poor source of vitamin D (Ziegler *et al.*, 2006). The amount of vitamin D in human breast milk is extremely limited, less than found in infant formula (usually 10 ug/L) (Alpert & Shaikh, 2007). Despite the amount of vitamin D metabolites present in human milk, which depends on the mother’s sun exposure and dietary intake, it still cannot meet the recommended intake of vitamin D, even in a vitamin D-sufficient mother (Misra et al., 2008).

2.2.7.4 Physiologicalcharacteristics

Skin pigmentation works as a natural sunscreen and may significantly reduce vitamin D synthesis (Clemens *et al.*, 1982). Several diseases, such asmalabsorption syndromes, renal disease and liver disease, may cause vitamin D deficiency as well through affecting the metabolism of 25(OH)D or 1,25$(OH)_2$D (Lo *et al.*, 1985). Elderly people have lower concentrations of 7-DHC, which is involved in the vitamin D pathway, and are thus prone to vitamin D insufficiency (Venning, 2005). Obesity can reduce the availability of vitamin D, leading to vitamin D insufficiency (Lagunova et al., 2009; Xu et al., 2006).

2.2.7.5 Medication

There are several medications that reduce vitamin D metabolism, such as anti-seizure drugs and glucocorticoids, and subsequently cause vitamin D deficiency in patients (Hossein-Nezhad & Holick, 2012).

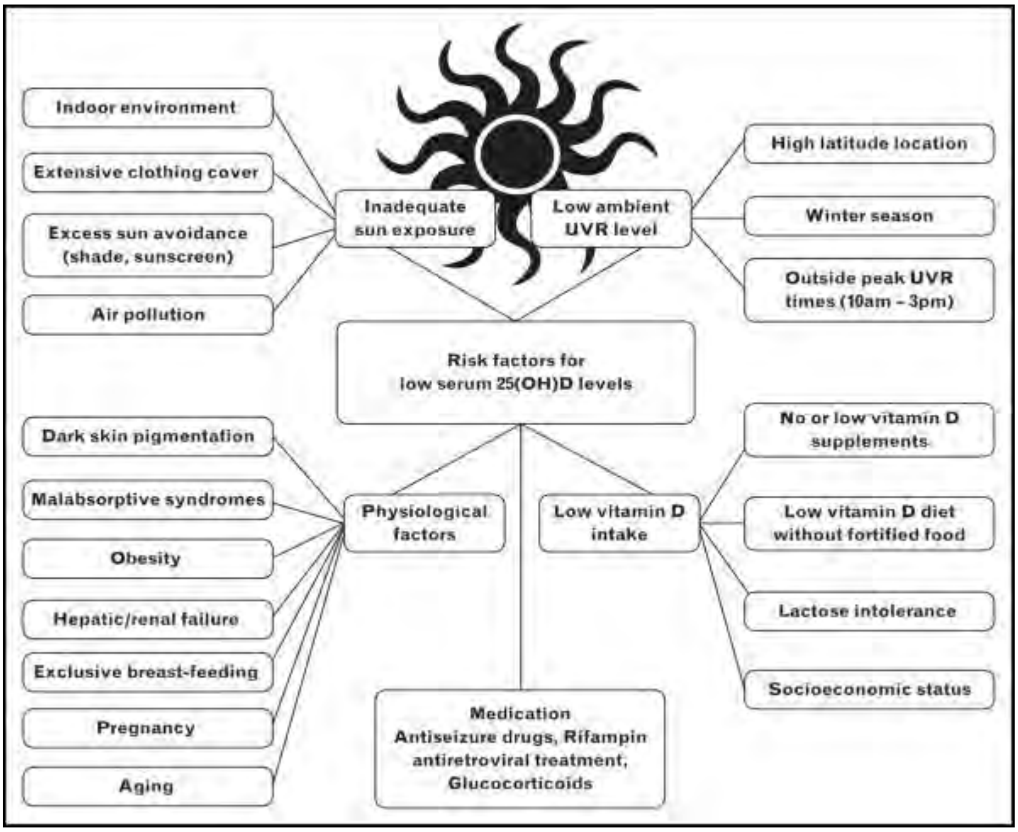


Figure 2.3 Causes of vitamin D deficiency, adapted from (Hossein-Nezhad & Holick, 2012)

2.2.8 Prevention and Treatment for Vitamin D Deficiency

Exposure to sunlight is the principal source of vitamin D for most people, but sun exposure also causes skin cancer. Thus, a balance is necessary between sufficient sun exposure, to reach adequate vitamin D generation, and minimize the risk of skin cancer (Sinclair, 2006).

As mentioned earlier, there are only few foods containing vitamin D naturally (Raiten & Picciano, 2004), and food-fortification strategies may not be sufficient to prevent vitamin D deficiency in current practice (Stroud *et al.*, 2008). Therefore, using supplements seems to be an alternative strategy to prevent vitamin D deficiency.

The 2010 USA IOM report on vitamin D suggests that an intake of vitamin D of 600 IU per day for ages 1-70 years and 800 IU per day for ages 71 and older, for both genders, are necessary(Ross et al., 2011). However, many vitamin D researchers do not support IOM recommendations, including Professor Michael Holick, a pioneer at vitamin D research, who has been working on vitamin D for over 40 years. He recommends a much high dose of vitamin D supplementation. Table 2.1 shows the recommendations of vitamin D supplementation in different populations by the IOM and Professor Michael Holick in 2011 (Holick, 2011). As illustrated, there is a striking difference between these two recommendations, based on the different evidence they believe in respectively. Hence, there is a great need to show more robust evidence to make a standard recommendation for vitamin D supplementation in the future.

Table 2.1 Vitamin D Recommendations by the IOM and Dr. Holick

Institute of Medicine Recommendations					Dr. Holick's Recommendations for Patients at Risk for Vitamin D Deficiency	
Life Stage Group	AI	EAR	RDA	Tolerable UL by the Institute of Medicine	Daily Allowance (IU/d)	UL (IU)
Infants						
0–6 mo	400 IU (10 μg)	—	—	1000 IU (25 μg)	400–1000	2000
6–12 mo	400 IU (10 μg)	—	—	1500 IU (38 μg)	400–1000	2000
Children						
1–3 y	—	400 IU (10 μg)	600 IU (15 μg)	2500 IU (63 μg)	600–1000	4000
4–8 y	—	400 IU (10 μg)	600 IU (15 μg)	3000 IU (75 μg)	600–1000	4000
Males						
9–13 y	—	400 IU (10 μg)	600 IU (15 μg)	4000 IU (100 μg)	1500–2000	4000
14–18 y	—	400 IU (10 μg)	600 IU (15 μg)	4000 IU (100 μg)	1500–2000	4000
19–30 y	—	400 IU (10 μg)	600 IU (15 μg)	4000 IU (100 μg)	1500–2000	10,000
31–50 y	—	400 IU (10 μg)	600 IU (15 μg)	4000 IU (100 μg)	1500–2000	10,000
51–70 y	—	400 IU (10 μg)	600 IU (15 μg)	4000 IU (100 μg)	1500–2000	10,000
>70 y	—	400 IU (10 μg)	800 IU (20 μg)	4000 IU (100 μg)	1500–2000	10,000
Females						
9–13 y	—	400 IU (10 μg)	600 IU (15 μg)	4000 IU (100 μg)	1500–2000	4000
14–18 y	—	400 IU (10 μg)	600 IU (15 μg)	4000 IU (100 μg)	1500–2000	4000
19–30 y	—	400 IU (10 μg)	600 IU (15 μg)	4000 IU (100 μg)	1500–2000	10,000
31–50 y	—	400 IU (10 μg)	600 IU (15 μg)	4000 IU (100 μg)	1500–2000	10,000
51–70 y	—	400 IU (10 μg)	600 IU (15 μg)	4000 IU (100 μg)	1500–2000	10,000
>70 y	—	400 IU (10 μg)	800 IU (20 μg)	4000 IU (100 μg)	1500–2000	10,000
Pregnancy						
14–18 y	—	400 IU (10 μg)	600 IU (15 μg)	4000 IU (100 μg)	1500–2000	10,000
19–30 y	—	400 IU (10 μg)	600 IU (15 μg)	4000 IU (100 μg)	1500–2000	10,000
31–50 y	—	400 IU (10 μg)	600 IU (15 μg)	4000 IU (100 μg)	1500–2000	10,000
Lactation*						
14–18 y	—	400 IU (10 μg)	600 IU (15 μg)	4000 IU (100 μg)	1500–2000	10,000
19–30 y	—	400 IU (10 μg)	600 IU (15 μg)	4000 IU (100 μg)	1500–2000	10,000
31–50 y	—	400 IU (10 μg)	600 IU (15 μg)	4000 IU (100 μg)	1500–2000	10,000

AI indicates recommended adequate intake; EAR, estimated average requirement; RDA, recommended dietary allowance.
*Lactating women need to ingest 4000 IU/day to put enough vitamin D in their milk.

AI: Adequate Intake, EAR: Estimated Average Requirement, RDA: Recommended Dietary Allowance, UL: Tolerable Upper Intake Level, 1 μg = 40 IU vitamin D

2.2.9 Vitamin D in Australia

Australia, as a country with high levels of ambient UV radiation, seems an unlikely location for high rates of vitamin D insufficiency. Dramatically, however, several studies have assessed the vitamin D status in Australia and show that the prevalence of vitamin D deficiency is much higher than expected (Kimlin *et al.*, 2007; van der Mei, 2007). In a cross-sectional study, in southeast Queensland, Australia, at the end of the 2006 winter, Kimlin *et al.*(2007) found that 10.2% of the participants had serum 25(OH)D levels below 25 nmol/L (considered deficient) and a further 32.3% had levels between 25 nmol/L and 50 nmol/L (considered insufficient) among 126 healthy, free-living adults (40 males, 86 females) aged 18 to 87 years. In another study, bringing together results from work in three different regions of Australia, vitamin D insufficiency appeared to be common over a wide latitude range in Australia (van der Mei *et al.*, 2007).

The major source of vitamin D in Australia is skin exposure to sunlight. But sun exposure also increases the risk of skin cancer, and Australia has one of the highest skin cancer rates in the world (Staples et al., 2006). Thus, people have been advised to decrease their sun exposure. At the same time, current lifestyle and work environments, such as working all day indoors and driving to and from work, may be contributing to limited sun exposure (Pasco *et al.*, 2001). Furthermore, the dietary intake of vitamin D of Australians is not sufficient to meet the vitamin D requirements and there are currently low levels of vitamin D fortification (Nowson & Marherison, 2002). Thus, the combination of these factors has led to a higher than expected prevalence of hypovitaminosis D in Australia.

There has been increasing awareness of this issue over the last several years, and efforts have been made to find an appropriate balance between sufficient sun exposure to obtain adequate vitamin D production and minimize the risk of skin cancer (Sinclair, 2006). Additionally, as using artificial UVB radiation is associated with health risks, this practice is not recommended individuals (Dore & Chignol, 2012). People at high risk of vitamin D deficiency who cannot get adequate vitamin D via sunlight are encouraged to take supplements (Nowson & Margerison, 2002). The current Australian guidelines for recommended vitamin D intake are: 200IU daily from birth to 50 years old, 400IU daily from 51 to 70 years old and 600 IU daily for people over 70 years of age (Lehmann & Meurer, 2010). More recently, a new position statement on vitamin D and health in adults in Australia and New Zealand has been published. Recommended vitamin D intakes from both foods and supplements are at least 600 μg per day for people ≤ 70 years and 800μg per day for elderly > 70 years(Nowson et al., 2012), which may achieve a target serum level of 25(OH)D ≥ 50 nmol/L by the end of winter.

2.3 VITAMIN D IN PREGNANCY

Pregnant women are at higher risk of vitamin D deficiency. In the following sections, the changing metabolism of vitamin D during pregnancy and possible health consequences of maternal vitamin D insufficiency are reviewed.

2.3.1 Adaptations of Vitamin D Metabolism in Pregnancy

The maternal body goes through several changes during pregnancy in order to optimize foetal growth. Significant changes in maternal vitamin D metabolism occur during pregnancy, as maternal vitamin D requirements are not only for the mother's own health, but also for foetal growth (Hollis, 2007). About 25 to 30 grams of calcium is transferred to the foetus by the end of pregnancy (Specker, 2004). During the first trimester, the foetus accumulates calcium two to three milligrams per day in its skeleton, but 250mg/day in the last trimester (Widdowson, 1981). There are three possible ways that increased calcium requirements can be met:

- increased maternal intestinal absorption of calcium,
- decreased maternal renal excretion of calcium, and
- increased resorption of calcium from the maternal skeleton (Specker, 2004).

However, despite the extra excretion, maternal serum calcium concentrations still gradually decline during the pregnancy, reaching the bottom level at mid-gestation, as a consequence of plasma volume expansion and decreased albumin concentrations (Salle *et al.*, 2000).

To adapt to these changes in serum calcium, the maternal concentration of 1,25$(OH)_2$D increases throughout pregnancy for increasing the efficiency of intestinal calcium absorption.In several studies, maternal serum concentrations of 1,25$(OH)_2$D increased during the first trimester of a normal pregnancy (Salle *et al.*, 2000), were 50 to 100% greater than in the non-pregnant state during the second trimester and 100% greater during the third trimester (Ritchie et al., 1998), all in relation to accumulating enough calcium to the foetus during pregnancy (Specker, 2004). Some of the 1,25$(OH)_2$D may come from other origins, as the deciduas has been shown to synthesize 1,25$(OH)_2$D (Delvin *et al.*, 1985). However, the results of the change of plasma 25(OH)D levels during pregnancy are inconclusive so far (Hien et al., 2011; Holmes et al., 2009).

A longitudinal study conducted by Holmes *et al*(2009) found that plasma 25(OH)D concentrations were significantly lower in pregnant women, compared to non-pregnant women, at 20 weeks ($P < 0.0001$) and 35 weeks of gestation ($P < 0.0001$). However, other studies have not replicated this finding (Hien et al., 2011).

2.3.2 Prevalence of Vitamin D Deficiency in Pregnancy

Reports are accumulating from many countries of a high prevalence of vitamin D deficiency in pregnant women, ranging from 5% to 84% (the large difference in percentage could be partly due to using different cut-off points) (Bodnar et al., 2007; Kazemi et al., 2009; Nicolaidou et al., 2006; Sachan et al., 2005). Thus, vitamin D deficiency during pregnancy is becoming a worldwide epidemic.

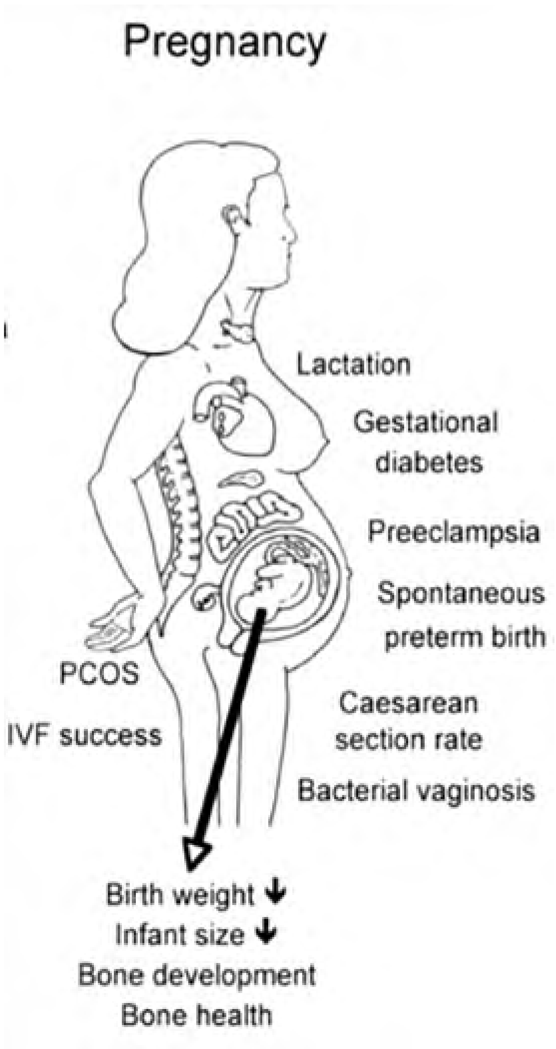
In a USA study, vitamin D insufficiency was reported to be common in both white and black pregnant women, even when mothers were compliant with prenatal vitamin D intake (Bodnar et al., 2007). It is reported that, at delivery, vitamin D deficiency (defined as 25(OH)D< 37.5 nmol/L) and insufficiency (25(OH)D 37.5-80nmol/L) occurred in 29.2% and 54.1% of black women, while 55% and 42.1% of white women, respectively. In west China, the authors assessed 67 pregnant women in September and found that the mean level of 25(OH)D was 36.0±19.7nmol/L, while 57.1% women showed vitamin D deficiency (25(OH)D < 37.5nmol/L) and 97.4% insufficiency (25(OH)D 37.5-80nmol/L) (Wang *et al.*, 2010).

In Australia, vitamin D deficiency was thought to be uncommon, even in pregnant women, however, in 2009, Bowyer *et al.*(2009) found that 15% of 971 pregnant women in south-eastern Sydney were vitamin D deficient (defined as 25(OH)D ≤25nmol/L). Another two studies carried out in Melbourne and in rural Victoria indicated that 7.2% of women's 25(OH)D concentrations were < 28nmol/L among 374 pregnant women in Melbourne (Morley *et al.*, 2006), and 25.7% women with 25(OH)D <50nmol/L among 330 pregnant women in rural Victoria (Teale & Cunningham, 2010).

Similarly, in an Indian study, a tropical country with abundant sunshine, the mean maternal serum 25(OH)D was just 35±22.5nmol/L (Sachan et al., 2005). In other work, the high prevalence of vitamin D deficiency in pregnant women has been demonstrated in a wide range of countries: 18% in the United Kingdom (Javaid et al., 2006), 46% in Canada (Weiler et al., 2005), over 80% in Belgium (Cavalier et al., 2008), 86% in winter and 46% in summer in Iran (Kazemi et al., 2009). These studies suggest that high latitude, pigmentation, the winter season or greater skin covering are global risk factors for hypovitaminosis D.

2.3.3 Maternal Health Consequences of Vitamin D Deficiency in Pregnancy

Low maternal vitamin D status around pregnancy has been associated with numerous adverse pregnancy outcomes. Figure 2.4 gives a summary of the possible health implications of vitamin D deficiency in pregnancy (Grundmann & von Versen-Höynck, 2011).



Note: PCOS= polycystic ovary syndrome; IVF= in vitro fertilisation

Figure 2.4 Possible implications of vitamin D deficiency in pregnancy

With regard to maternal outcomes, vitamin D deficiency during pregnancy is not only important for maternal skeletal preservation. Emerging research suggests that vitamin D deficiency may be associated with an increased risk of preeclampsia, insulin resistance and gestational diabetes mellitus, as well as primary caesarean section and bacterial vaginosis.

2.3.3.1 Bone health

An overall 2% to 5% of maternal bone loss was observed during whole pregnancy (More *et al.*, 2001; Olausson *et al.*, 2009). Several cases of pregnancy-associated osteoporosis have been reported (Kabi *et al.*, 2006; Stumpf *et al.*, 2007). However, no study directly assessed whether vitamin D deficiency affected maternal bone health during pregnancy. Only one study showed that pregnant women had greater bone loss in winter than those in summer, which suggested a possible vitamin D effect (Javaid et al., 2005).

2.3.3.2 Preeclampsia

Vitamin D is thought to have both direct and indirect effects on various mechanisms related to the pathophysiology of preeclampsia, such as immune dysfunction, hypertension and inflammation(LaMarca *et al.*, 2008). A case-control study showed a significant association between 25(OH)D concentrations in early pregnancy and subsequent preeclampsia (Bodnar et al., 2007). In this study, pregnant women with 25(OH)D levels <37.5ng/mL had a five-fold increase in the risk of preeclampsia. Another prospective study found a 27% reduction in risk of preeclampsia for pregnant women taking 10 to 15μg/d (400 to 600IU per day) of vitamin D as compared with no supplements (OR=0.73, 95%CI: 0.58-0.92) (Haugen et al., 2009). These findings support that vitamin D exerts a protective effect on preeclampsia development (Mulligan *et al.*, 2009).

2.3.3.3 Gestational diabetes mellitus (GDM)

Evidence also suggests a role for vitamin D in maintaining normal glucose homeostasis (Peechakara & Pittas, 2008). It is known that $1,25(OH)_2D$ stimulates insulin secretion as one of its non-classic functions. Some studies have found an inverse association between maternal plasma 25(OH)D concentrations and the risk of GDM and higher fasting glucose levels (Clifton-Bligh et al., 2008; Maghbooli et al., 2008; Zhang et al., 2008).

Zhang *et al.*(2008) conducted a nested, case-control study with 953 pregnant women and found that maternal plasma 25(OH)D concentrations, at an average of 16 weeks of gestation, were significantly lower in women who subsequently developed GDM, compared to controls. The authors also reported that each 12.5nmol per litre decrease in 25(OH)D concentrations was related to a 1.29-fold increase in GDM risk among non-Hispanic, white subjects (OR=1.29, 95% CI: 1.05-1.60).

2.3.3.4 Primary caesarean section and bacterial vaginosis

Other unexpected maternal outcomes may be linked to low vitamin D status as well. Recently, Merewood *et al.*(2009) found that there was an inverse association between serum 25(OH)D levels and the risk of having a primary caesarean section. In multivariable, logistic, regression analysis, controlling for race, age, education level, insurance status and alcohol use, women with 25(OH)D < 37.5nmol/L were almost four times more likely to have a caesarean section than women with 25(OH)D $\geq$ 37.5nmol/L (adjusted OR=3.84; 95% CI: 1.71-8.62) (Merewood *et al.*, 2009). This finding can be explained partly by poor muscular function, which has been an established consequence of vitamin D deficiency (Ceglia, 2009). In addition, Bondar *et al.*(2009) reported that maternal vitamin D deficiency was associated with bacterial vaginosis in the first trimester of pregnancy, possibly through the actions of $1,25(OH)_2D$ on the immune system. Bacterial vaginosis prevalence decreased as vitamin D status improved ($P < 0.001$). Approximately 57% of the women with a serum 25(OH)D concentration < 20 nmol/L had bacterial vaginosis, compared with 23% of women with a serum 25(OH)D concentration > 80nmol/L.

2.3.4 Offspring Health Consequences of Maternal Vitamin D Deficiency in Pregnancy

There is increasing evidence showing a correlation between cord and maternal blood concentrations of 25(OH)D (Wang, 2010; Kazemi et al., 2009; Nicolaidou et al., 2006). Adequate vitamin D status during pregnancy is indispensable because it guarantees proper maternal responses to the calcium demands of the foetus and neonate (Specker, 2004), as their vitamin D stores are completely dependent on the mothers (Kovacs, 2008). Furthermore, because vitamin D is involved in a broad range of physiological processes besides skeletal formation, vitamin D may also have other consequences for the health of the foetus later in life, as well as soon after birth.

2.3.4.1 Skeletal consequences

There are case reports of hypocalcaemia and congenital rickets to those with severe maternal vitamin D deficiency. In one study, the authors reported a case series of 19 newborn infants who presented with symptomatic hypocalcemia as a secondary disorder to maternal vitamin D deficiency (Teaema & Al Ansari, 2010). There was also a significant correlation between the newborn infants and their mothers 25(OH)D levels (r = 0.403, P = 0.01). In another report, four newborn infants with congenital rickets are detailed whose mothers had evidence of vitamin D deficiency (Innes et al., 2002).

Congenital rickets is usually found in infants when their mothers have severe vitamin D deficiency. With mild to moderate maternal vitamin D deficiency, symptoms and signs may not be seen directly and clearly. However, with the advances of technology, researchers can use quantitative tools for comparison of bone development in utero. Mahon and his colleagues (2009) used high-resolution, 3D, ultrasound analysis to measure foetal femur length and distal metaphyseal cross-sectional area at 19 and 34 weeks' gestation, and found that there was no association between maternal 25(OH)D concentration and foetal femur length, but low maternal 25(OH)D concentration was related to a greater femoral metaphyseal cross-sectional area and a higher femoral splaying index in the foetus.

Long-term impacts on bone were also observed in two longitudinal cohort studies. Compared with those born to mothers with 25(OH)D levels > 50 nmol/L, children born to mothers with levels < 27.5 nmol/L have lower total and lumbar bone mineral density measured by dual energy X-ray absorptiometry at 9 years of age (Javaid et al., 2006). Children born to mothers with 25(OH)D< 42.6 nmol/L have lower tibia cross-sectional area at birth, compared to those born to mothers with 25(OH)D > 42.6 nmol/L, which is sustained at 14 months old (Viljakainen et al., 2011).

2.3.4.2 Non-skeletal consequences

Other potential adverse outcomes, besides bone health on offspring due to maternal vitamin D deficiency during pregnancy, are now being revealed. A number of studies have suggested an association between maternal vitamin D deficiency and non-bone diseases and/or abnormal development in the offspring.

(a) Birth size

Several studies have investigated the relationship between maternal vitamin D status and neonatal size. A study in Iran observed 449 pregnant women and their newborns in pairs. Mean length at birth was higher in newborns whose mothers had adequate calcium and vitamin D intake than those whose mothers had inadequate intake (P=0.03). A significant correlation was also found between adequate maternal intake of calcium and vitamin D, and appropriate birth weight (Sabour et al., 2006). Another study in 307 pregnant women in Canada ascertained that each additional microgram of vitamin D in the mother during pregnancy caused an 11 gram increase (95% CI: 1.2–20.7 g) in the birth weight of the baby (Mannion *et al.*, 2006).

In contrast to the findings above, Sachan *et al.*(2005) studied 207 urban and rural pregnant women at full term in northern India. The researchers found a high prevalence of vitamin D deficiency among pregnant women and their newborns, but neonates did not differ in anthropometry. Similar results reported in another study undertaken in Gambia showed a lack of significant relationship between maternal vitamin D status and any of the following infant measures: birth weight, infant length at 13 weeks postpartum and infant head circumference at 52 weeks postpartum (Prentice *et al.*, 2009). Multiple confounding factors could be investigated for vitamin D status on gestational baby size. Larger, randomized, control trials to address the relationship between vitamin D and birth size, need to be undertaken.

(b) Small for gestational age (SGA) infant

SGA is reported relative to maternal vitamin D status in several studies. A double-blind trial conducted in Great Britain found that supplemental vitamin D (1,000 IU/d starting in the third trimester) reduced the risk of SGA compared with a placebo (15% versus 29%, p< 0.001) (Brooke et al., 1980). In a nested, case-control study, a U-shaped risk relationship is observed between SGA and maternal 25(OH)D concentrations in white women (Bodnar et al., 2010). An observational study by Leffelaar*et al.*(2010) found that maternal 25(OH)D levels < 30 nmol/L are associated with an increased risk of SGA (OR=1.9, 95% CI: 1.4-2.7) after adjustment for all of the potential confounders.

(c) Brain disorders

Experimental animal studies indicate that vitamin D is involved in brain development (Cui *et al.*, 2007; O'Loane*t al.*, 2007). Prenatal vitamin D deficiency was found to reduce the amount of apoptotic cell death, which is usually linked to neuronal differentiation (Ko *et al.*, 2004). Evidence provides support for an association between the prenatal vitamin D environment and the risk of later development of schizophrenia (McGrath et al., 2010). After analysing epidemiological data, seasonal variation of birth rates and prevalence of infantile autism, Grant and his colleague (2009) concluded that maternal vitamin D deficiency is a risk factor for infantile autism disease. Furthermore, a later study found that the risk of women with vitamin D ≤46 nmol/L during pregnancy having a child with clinically significant language difficulties was increased almost twofold, compared with women with vitamin D levels >70 nmol/L (Whitehouse et al., 2011).

(d) Inflammatory andimmune disorders

A case-control study has reported that lower maternal 25(OH)D levels were associated with an increased risk of acute lower respiratory tract infection in neonates (Karatekin *et al.*, 2007). Moreover, in a more recent, prospective cohort study, Morales *et al.*(2012) found a statistically significant trend between higher levels of maternal circulating 25(OH)D levels in pregnancy and decreased odds of lower respiratory tract infection in offspring (OR = 0.67, 95% CI: 0.50–0.90, test for trend, P = 0.016).

Vitamin D insufficiency during pregnancy is also associated with increased prevalence of islet cell antibodies in offspring, and the incidence of childhood type I diabetes was reduced in mothers who took vitamin D supplements, compared to those who did not (Stene*et al.*, 2000).

A sub-study from the Nurses' Health Study II in the USA found that higher maternal milk and vitamin D intake during pregnancy may be associated with a lower risk of offspring developing multiple sclerosis (MS) (Mirzaei et al., 2011).

Additionally, there is some evidence to suggest that low maternal vitamin D intake may be associated with the risk of recurrent wheezing in offspring (Devereux *et al.*, 2007). Eczema, hay fever or allergic rhinitis are also found to be more common in children whose mothers had low vitamin D intake during pregnancy (Camargo et al., 2007; Devereux et al., 2007; Erkkola et al., 2009). These findings imply that low maternal vitamin D levels possibly increase the risk of an allergy propensity in offspring.

2.4 STUDIES OFBEHAVIOURS IN RELATION TO VITAMIN D

As mentioned earlier, the main determinants of vitamin D status are skin exposure to sunlight and intake of vitamin D (Holick, 2007). Therefore, individual vitamin D status is affected by his/her sun exposure behaviours, such as outdoor time, clothing and sunscreen use, and dietary behaviour. Several studies have been conducted to investigate these behaviours in different populations.

Studies have been conducted about the outdoor time spent in European countries and the USA. A study, called 'EXPOLIS' (population sampling in European air pollution exposure study) showed that the average outdoor time was about 90 minutes per day for the adult population in seven European cities (Helsinki, Athens, Basel, Grenoble, Milan, Prague and Oxford) (Rotko *et al.*, 2000). In the United Kingdom, 124 healthy adults reported a mean outdoor time of 3.8 hours per day during in summer (Stafford et al., 2010). A nationwide cohort in the USA found that the mean daily times spent outdoors between 9 am and 5 pm were 1.37 hours on weekdays and 2.22 hours on weekends, respectively, among 124 radiological technologists, according to their personal activity diaries (Chodick et al., 2008). Godar*et al.*(2011) also revealed that the outdoor time spent by adults in the USA was approximately 90 to 100 minutes per day. One study of an Australian population, by Dobbinson*et al.*, reported that Australian adults spent an average of 110 minutes outdoors during peak UV period from 10 am to 2 pm on summer weekends. However, no data was found regarding the time spent outdoors by pregnant women either in Australia or in other countries.

Clothing is important as it regulates the amount of skin exposure to sunlight, which, in turn, impacts on vitamin D synthesis cutaneously (Springbett *et al.*, 2010).With regard to patterns for the use of clothing in the sun, a few studies have been conducted in Australia. Recently, Naomo *et al.*(2012)reported on sun protective behaviours among 1,113 adults in an Australian, subtropical community. There were 39% people wearing a hat "almost always", with 10% "almost never/never". However, 65% people "almost never/never" wore long sleeves; only 6% indicated that they "almost always" wore them. Furthermore, 39% of the subjects chose to wear sunglasses "almost always", while 25% chose "almost never/never". Another Australian study suggested that only 15% of the female population was wearing long sleeves in 2001 (Dobbinson *et al.*, 2002).

Sunscreen use is one of the commonly reported sun protective behaviours in the world (Centers for Disease Control and Prevention, 2012).Four hundred and fifteen pregnant women were surveyed with regard to sunscreen use in France, of whom 17.3% reported the use of sunscreen (Benchikhi *et al.*, 2002). Another study in the USA showed that 34.6% of pregnant women applied sunscreen (Merewood et al., 2010). There were no data on Australian pregnant women, but sunscreen use appeared to be more popular in Australia than in other countries (Stanton *et al.*, 2004). Dobbinson *et al*.(2002) reported that the prevalence of sunscreen use in females living in Melbourne was 46%.

In relation to vitamin D intake among pregnant women in different countries. Scholl *et al.*(2009) found that the vitamin D intake was 4.81 ± 0.074 µg per day from diet in 2,251 pregnant women in the USA. Carmargo*et al.*(2007) reported in their study that the mean vitamin D intake from food during pregnancy was 5.625 µg per day in eastern Massachusetts, USA. Similarly, in a population of pregnant Finnish women, the mean daily intake of vitamin D was 5.1 µg from food (Marjamäki et al., 2010). More recently, a large, observational study in Denmark discovered that the mean dietary vitamin D intake was 3.56 ± 2.05 µg per day among 68,447 pregnant women (Jensen et al., 2012).

In terms of supplementation, the amount of vitamin D derived from supplements varies a lot depending on the study population and site. The amount of vitamin D from supplements in 2,215 low income, minority gravidae from Camden, USA, was

5.50±0.047 μg per day (Scholl & Chen, 2009). Marjamaki *et al*.(2010) observed that the mean daily intake of vitamin D was only 1.3 μg per day from supplements in a pregnant, Finnish women population. Viljaka *et al*.(2010) reported in their study that 80% of women used vitamin D supplements during pregnancy, with the average vitamin D from supplementation being 6.6 ± 4.8 μg per day. More recently, among 68,447 pregnant, Danish women, 67.6% reported the use of vitamin D supplements in any dose, but only 36.9% were at a ≥ 10 μg per day dose (foods + supplements), which is the dose now recommended in Denmark for pregnant women, and the mean vitamin D intake from supplements was 5.67 ± 5.20 μg per day (Jensen et al., 2012). There was one Australian study investigating vitamin D intake in 201 pregnant women and only 12 participants had an intake ≥ 10 μg (400 IU) of vitamin D daily (Perampalam et al., 2011).

2.5 SUMMARY

As detailed above, vitamin D deficiency in pregnant women is common, and this may be linked with a wide array of biological effects, which may impair maternal or offspring health, or both (Thorne-Lyman & Fawzi, 2012). However, basic, observational data about pregnant women's sun exposure behaviours and vitamin D intake, which may affect their vitamin D status, are limited.

Additionally, the epidemiological evidence about recommendations for pregnant women is still incomplete. In consideration of the high prevalence of vitamin D deficiency in pregnant women, and making effective strategies to prevent this issue, it is important to understand how pregnant women behave in regard to sun exposure and vitamin D intake. Thus, this study was conducted to investigate sun exposure and protective behaviours, dietary vitamin D intake and vitamin D supplement usage during pregnancy in Australia.

Chapter 3: Research Design

This chapter describes the designs adopted by this study to achieve the aim and objectives described in Chapter 1. First of all, a description of the research design is given in section 3.1. Then, sample inclusion criteria and sample size calculations are detailed in section 3.2. Section 3.3 illustrates the questionnaires development, followed by the procedure of launching survey and data collection. The major variables will be described in section 3.9. Finally, issues relating to data analysis and ethical clearance will also be discussed.

3.1 RESEARCH DESIGN

An exploratory, descriptive design was selected by using web-based questionnaires to collect data. The rationale for using an online medium was to enable access to nationwide and diverse groups of potential research participants and to present a cross-cultural dimension. The software used to develop and distribute online surveys in this study was Key Survey, which is an official, web-based, survey creation and management system from Queensland University of Technology (QUT). It is freely provided to all QUT staff and students, with support provided by the High Performance Computing Group. Details of this software can be found at https://survey.qut.edu.au/site/.

The study constituted two main parts, both of which were web-based questionnaires.

- The first part, the baseline survey, was completed by participants during their pregnancy to identify their vitamin D related behaviours and potential influencing factors.
- The second part was a follow-up, pilot survey, which was completed by the women who were involved in the initial survey, after their delivery to assess their pregnancy outcomes.

3.2 SAMPLE

3.2.1 Inclusion Criteria

This study recruited adult, pregnant women living in Australia and, to avoid early stage miscarriage and consequently to increase the follow-up ratio, three inclusion criteria were developed. That is, participants must have been:

- living in Australia;
- aged 18 years or over; and
- at least three months pregnant.

3.2.2 Sample Size Calculation

The key research question ("How do pregnant women behave in relation to vitamin D in Australia?") was used for sample size calculation. There were five sub-questions for five types of behaviour. The calculated sample sizes were different for different sub-questions and the largest one was used to determine the size for the whole project. There are two formulae applied to calculate sample size, depending on different data types.

For mean, this formula is

$$n = \left[\frac{Z_{\alpha/2}\sigma}{\mathrm{E}} \right]^2$$

where n is the required sample size, $Z_{\alpha/2}$ is the critical value, σ is the population standard deviation and E is the maximum margin for error.

For proportion, the formula is:

$$n = \frac{\left(Z_{\alpha/2}\right)^2 p(1-p)}{E^2}$$

where n is the required sample size, $Z_{\alpha/2}$ is the critical value, p is the anticipated population proportion and E is the maximum margin for error.

Therefore, five sample sizes for five sub-questions were calculated. For outdoor time, it is 139. For body surface area covered by clothing, it is 96. For sunscreen use it is 96. For dietary vitamin D intake, it is 93. Last, for vitamin D supplement, it is 89.

Consequently, a minimum of 139 participants were deemed to be sufficient in order to estimate the mean levels or prevalence of five types of vitamin D related behaviour, with a certain degree of accuracy. It appeared likely to be underpowered in order to detect the relationships between these behaviours and influencing factors, and other variables. However, due to the limits in time and budget, the sample size for this project was determined based only on the key research question. Secondary research questions were addressed in an exploratory manner.

3.3 QUESTIONNAIRE DEVELOPMENT

There were two online surveys in this study: A baseline survey, finished during pregnancy, and a follow-up survey, completed in the early postpartum period. In the baseline survey, the questionnaires were based on the National Health and Medical Research Council (NHMRC) funded, multi-site AusD study undertaken by Professor Michael Kimlin*et al.* This was a large study investigating the factors that influenced vitamin D production in Australian adults between 2008 and 2010. A few modifications were made, due to the unique features of this study (the participants were pregnant women and the instrument was web-based). For the follow-up survey, the questionnaire was developed following an extensive literature review about potential relationships between maternal 25(OH)D levels during pregnancy and pregnancy outcomes (Hollis & Wagner, 2012; Lapillonne, 2009; Sharon et al., 2010). The questions were selected according to how appropriate and relevant they were to the research objectives.

The final version of the baseline survey consisted of three questionnaires (Part A, Part B and Part C), and the follow-up survey consisted of one questionnaire (Part D).

3.3.1 The Baseline Survey

3.3.1.1 Part A: General Health and Information Questionnaire

Part A was the first questionnaire provided to participants. It consisted of six sections and collected data about important demographic and obstetrical variables.

Section One gathered the following data from participants: date of birth, country of birth, years of living in Australia, parents' ethnicity, education level, employment status, indoor or outdoor occupation status. Section Two captured smoking and alcohol consumption. Section Three asked for general health information, including the participants' self-assessed health rating and any cancer diagnoses that they may have had in the past. Section Four collected data about participants' prescription medication, and asked participants whether they had had any of several diseases related to vitamin D deficiency. It also asked about any medicine in current use. Section Five captured pregnancy health information: the estimated date of delivery, gestational age, pre-pregnancy weight, current weight, height, gravidity and parity. Section Six gathered data about vitamin D supplementation usage.

Modifications from the original questionnaire used in the AusD study included the deletion of some questions that were not suitable for pregnant women, such as taking oral contraceptives, but added some questions regarding pregnancy information, such as the number of weeks of pregnancy, as well as gravidity and parity (see Appendix A for a copy of questionnaire Part A).

3.3.1.2 Part B: Sun Exposure Questionnaire

The sun exposure questionnaire was provided to participants following vitamin D supplementation to assess participants' skin status and sun exposure behaviour. It consisted of five sections. Section One collected information about skin types and sun exposure, including skin colour and reaction to the sun when skin is exposed. Section Two captured the data about typical sun exposure for the previous month. Section Three gathered sun protective behaviour information, such as using clothing, sun glasses, and sunscreen. Data about dietary intake of vitamin D was collected in Section Four, and information about physical activity in the past seven days was requested in the last section, Section Five.

Modifications from the original questionnaire used in the AusD study included: the addition of asking for skin colour, because pigment would influence vitamin D synthesis; simplified questions indicating the body parts where sunscreen was applied; and dietary intake of vitamin D, to make the survey shorter and clearer to reduce subject burden. There were also some format modifications to fit with online survey features (see Appendix A for a copy of questionnaire Part B).

3.3.1.3 Part C: Sun and Vitamin D Knowledge and Attitudes Questionnaire

Fifteen questions focused on the participants' knowledge of vitamin D, such as listing health problems if vitamin D was inadequate, symptoms and signs of vitamin D inadequacy, ways to attain sufficient vitamin D, and attitudes to sun exposure and suntans. Part C also collected data about participants' feelings about themselves, for example, "Have you been able to concentrate on what you're doing?", "Have you felt you were playing a useful part in things?" and "Have you been feeling unhappy or depressed?"

There were no changes from the original questionnaire used in the AusD study except some format modifications to fit with online survey features (see Appendix A for a copy of questionnaire Part C).

3.3.2 The Follow-up Survey

3.3.2.1 Part D: Pregnancy Outcomes and Maternal Knowledge and Attitudes to Vitamin D for Their Newborn Infants

This follow-up, pilot survey was applied to previous participants of the baseline survey. They were asked to complete it in the early postpartum period (in the first two months). The questions captured pregnancy outcomes, such as the type of delivery, as well as the baby's gender, birth weight and birth length. It was infeasible to take blood samples from participants to measure their 25(OH)D levels, as they were living in many places throughout Australia. Instead, a question was set up asking if the participants had had their vitamin D level tested during pregnancy. If a participant ticked "yes", this question was followed by one requesting information about when the test took place and what the result was. In addition, participants where questioned about maternal attitudes to giving their babies vitamin D supplements and how they would like to expose their baby to the sun (see Appendix B for a copy of questionnaire Part D).

3.4 SURVEY TEST AND ACTIVATION

The validity of the survey questions was assessed through a three-step process. First, the questionnaires derived from the AusD study were modified in accordance with participants' features (pregnant females) and existing literature. Next, subject matter experts were consulted and asked to comment on the content of the data collection instrument, in order to determine whether the items reflected the objectives of the study. Finally, pilot test respondents, who were not included in this study, were asked to evaluate and provide comments on the overall design of the questionnaires, the content, response options and clarity of the wording. Also tested was the feasibility of using an online medium for data collection, to confirm the robustness of the electronic questionnaires and to identify any procedural issues prior to undertaking the official launch.

After the above measures, with the assistance of a specialist working at the High Performance Computing & Research Support Department of QUT, the initial survey was opened to public access, with its own unique uniform resource locator (URL) address: http://survey.qut.edu.au/survey/171369/26ca/

3.5 RECRUITMENT

Firstly, this study was introduced on the website for the Centre for Research Excellence in Sun and Health (CRESH) athttp://www.cresunandhealth.org.au. The CRESH was founded by the NHMRC, aiming to build an evidence base regarding the adverse and beneficial effects of sun exposure, which is led by Professor Michael Kimlin. CRESH brings together a multidisciplinary and complementary team, including clinicians, medical and/or health scientists, epidemiologists, behavioural researchers and psychologists, public health physicians and health economists, who were all very likely to forward the study link to potential participants.

Secondly, a media campaign was released by the QUT media department via both the Internet and newspaper. The Internet link to this story was:

http://www.news.qut.edu.au/cgibin/WebObjects/News.woa/wa/goNewsPage?newsEventID=36117 .The study was advertised in several newspapers, namely the Newcastle Herald, the Sunday Mail Brisbane, the Adelaide Advertiser, the Morning Bulletin, the Western Advocate, AAP Newswire (see Appendix E for a copy of the advertisement).The study was also shared on the Facebook page for QUT.

Thirdly, a search was undertaken to identify web-based, pregnant women's sites and discussion fora, as possible avenues where the study could be promoted. The criteria used to select suitable expectant mothers', online sites and discussion fora were as follows:

- the site or forum must be run for mothers-to-be;
- it must be open to this research process;
- it must have had activity within the previous 10 days.

Each site's credentials were checked and, if the site was considered appropriate, the individual moderators of each site were contacted by email, informed of the study and permission was sought to post details of the study on the site.

Recruitment notices were placed on the following websites: the Australian Breastfeeding Association online forum, the Bub Hub online forum, Australian Mum, the Essential Baby online forum, Kidspot Australia and the bellybelly online forum.

Information about the study was also distributed on related, public, Facebook pages, such as Midwives Australia, Midwives Naturally, mybirth, and Pregnancy.

3.6 RESEARCH ADMINSTRATION

Details of the study were provided in all of the advertisements placed. When a potential participant entered or clicked on the web address, it automatically took her to information about the study, which explained the aim of the study, method of data collection, inclusion criteria, expected benefits and risks. Each potential participant was also informed that their involvement in this study was on a voluntary basis and that all of the information she gave, especially identifying information, would be kept confidential. Telephone numbers and email addresses were provided and each participant was advised to contact the main researcher directly if she required any additional information. A few participants emailed the researchers stating their willingness to take part in the study and their interest in the results.

3.7 DATA COLLECTION

Recruitment commenced in June 2011 and closed in February 2012.

Potential research participants, who were interested in this study upon noticing the advertisement(s), could log on to the baseline survey directly through the given URL (website address). After reading the Participant Information Sheet for QUT Research Project (PIS) and Participant Consent Form, participants clicked "I ACCEPT" to take part and moved on to complete three online questionnaires: Parts A, B and C. This part of the survey took, on average, 40 minutes and ended with a short thank you message. There were no monetary incentives provided to the participants.

Then, according to the estimated delivery date that the participants noted in the baseline survey, an invitation letter was sent via email or normal post, or, if neither of the former two contact methods were available, a text message was sent to the mobile (cell) telephones of those participants who had been estimated to have given birth, in order to invite them to complete the follow-up survey in the early postpartum period. The web address http://survey.qut.edu.au/survey/171399/ba7a/ was identified in the invitation letter to enable participants to access the follow-up survey directly. The follow-up survey consisted of one questionnaire: Part D. This survey took about five minutes to complete and had a short thank you message at the end. If participants had any questions, they were encouraged to contact the main researcher.

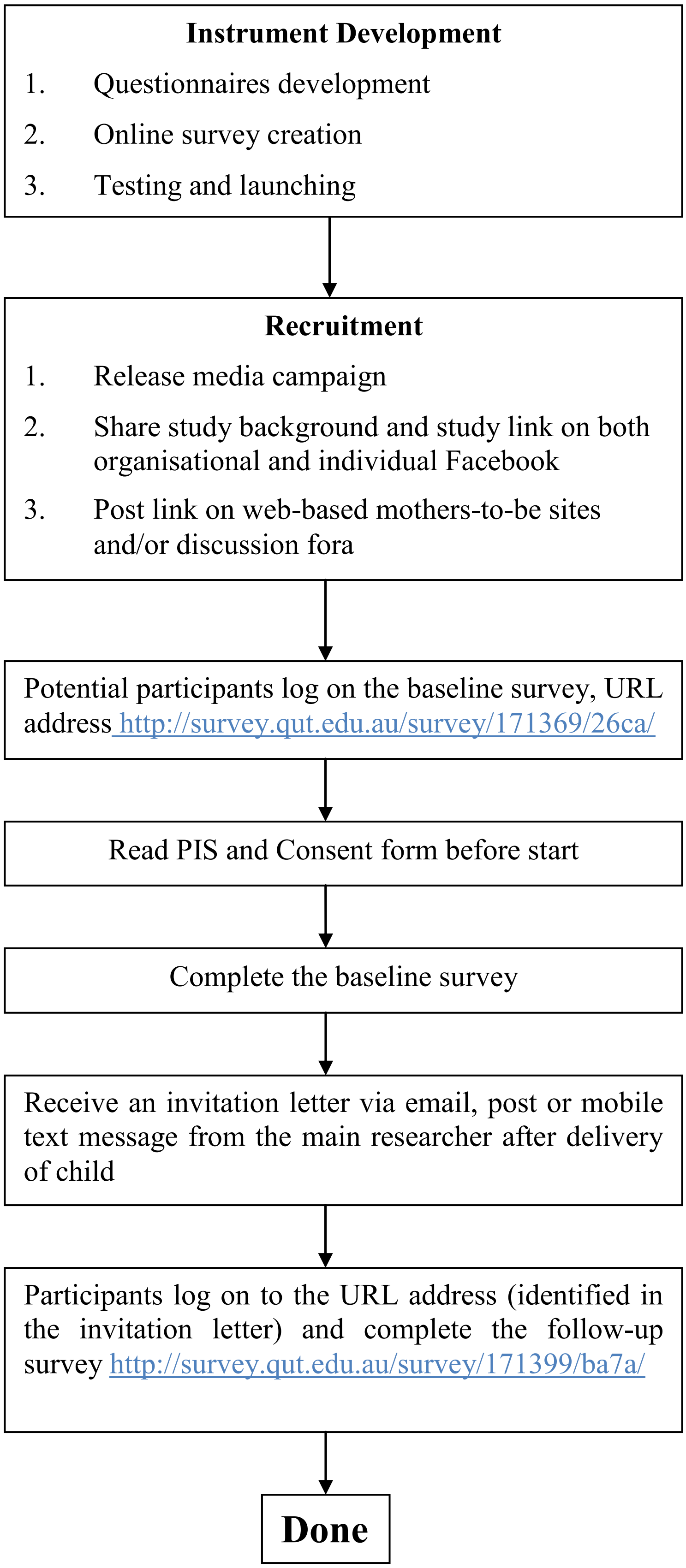


Figure 3.1 Flowchart of data collection procedures

3.8 THE MAJOR VARIABLES IN THIS THESIS

Not all the data collected were presented in this thesis, due to time availability and energy ability. According to the main aim and objectives of the thesis, a detailed description of major variables was given herein. The data out scope of this thesis will be presented later as publications of original research.

3.8.1 Dependent Variables

Maternal sun exposure and sun protective behaviours, dietary vitamin D intake and vitamin D supplement use were the dependent variables of this thesis. Sun exposure and sun protective behaviours were assessed by using “outdoor time”, “clothing” and “sunscreen use”. Further, vitamin D intake behaviours “dietary vitamin D intake” and “vitamin D supplement”, which, of the five terms, were called maternal “vitamin D related behaviours” in this thesis.

3.8.1.1 Outdoor time

Seven questions were given to participants asking the usual length of time that they spent outside between sunrise and sunset (from 5 am to 7 pm) on a typical Monday, Tuesday, Wednesday, Thursday, Friday, Saturday and Sunday in the past month, with five frequency options ranging from “Never”, “<15minutes”, “15-30minutes”, “30-45minutes” and “45-60 minutes” for every hour from 5 am to 7 pm of total 14-hour period (see Appendix A, a copy of Survey One at questions 51-57).

For convenience when calculating outdoor time, the median value of each option was adopted, that “Never” = 0 minutes, “<15minutes” = 7.5minutes, “15-30minutes” = 22.5 minutes, “30-45minutes” = 37.5 minutes and “45-60 minutes” = 52.5 minutes. Thus, an estimate was able to be made of each pregnant woman’s outdoor time every day, and even every hour.

(a) Everyday outdoor time during the daytime (5 am to 7 pm), in minutes per day

$$\text{Outdoor time} = \sum_{i=1}^{14} O_i$$

- Where ‘O_i’ is during the hour i, the time (in minutes) spent outdoors.
- ‘14’ means total 14 hours from 5am to 7pm.

(b) Everyday outdoor time during the daytime (5 am to 7 pm) – UV was adjusted

This was due to the variation in doses of UV radiation from hour to hour in one day, usually in a bell-curve shape, peaking at the middle of the day (see Figure 3.2 below).

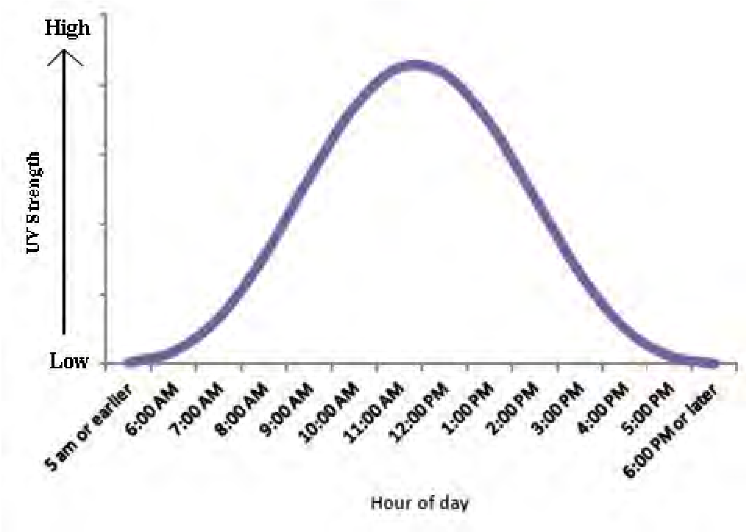


Figure 3.2 Hourly distribution of the strength of UV radiation

As has been addressed in literature review, the strength of ambient UV radiation is related to vitamin D synthesis. Generally, the higher the ambient UV radiation, the more vitamin D is produced in skin. So, to make the outdoor time equivalent for synthesis of vitamin D through sun exposure, a UV weight was assigned to every hour outdoor of time (see Table 3.1). In this thesis, this is called 'UV adjusted outdoor time' and the following formula, which was developed by Professor Michael Kimlin in 1998 (Kimlin *et al.*, 1998), was adopted with some modifications made by Doctor Jiandong Sun, based on AusD data. Thus,

UV-adjusted outdoor time = $\sum_{i=1}^{14} O_i \times W_i$

- Where 'O_i' is during the time period i, the time (in minutes) spent outdoors.
- 'W_i' is the UV weight during the time period i, as shown in Table 3.1.

Table 3.1 UV weight at different time period

Time period	UV weight	Proportion of daily UV radiation
5am-6am	0.016	0.001
6am-7am	0.106	0.008
7am-8am	0.377	0.027
8am-9am	0.867	0.062
9am-10am	1.496	0.107
10am-11am	2.063	0.147
11am-12am	2.378	0.170
12 am-1pm	2.329	0.166
1pm-2pm	1.934	0.138
2pm-3pm	1.337	0.095
3pm-4pm	0.733	0.052
4pm-5pm	0.290	0.021
5pm-6pm	0.067	0.005
6pm-7pm	0.007	0.001
Total	1.000	1.000

Using the formula above, the UV adjusted time spent outdoors every typical day in a week was calculated, then the times for each of the seven days were added together to ascertain a whole week of UV adjusted outdoor time. After that, the whole week's time was divided by seven to calculate an average outdoor time in one day weighted by UV, namely 'daily UV adjusted outdoor time'.

3.8.1.2 Clothing

The specific questions about clothing (see Appendix A, a copy of Survey One at question 64) asked if the respondents usually:

- wear a broad-brimmed hat?
- wear a cap?
- wear any other head covering?
- wear a shirt with long sleeves?
- wear long trousers or clothing that covers all or most of their legs?
- wear sunglasses?

Participants were asked to rate the frequency of wearing different items of clothing in the past month on a 4-point Likert scale ranging from "Never/Rarely", "Less than half of the time", "More than half the time", to "Always/Almost always".

(a) Scoring the clothing

To score the clothing data, the frequency was allocated a score of: "Never/Rarely"= 0, "Less than half of the time" = 1, "More than half the time" =2 and "Always/Almost always" = 3.

The formula below, which was developed by Doctor Jiandong Sun based on AusD data, was used to calculate the total clothing score for every participant.

Due to the apparent overlap between the first three questions about head covering, these were combined to one for scoring—the highest score of three was assigned to the new variable "head cover". Further, because the area surrounding the eyes that is protected by sunglasses had been included in head cover already, sunglasses were excluded from the scoring as well. Thus,

Total clothing score = (head cover frequency score × 0.4 + long-sleeved shirt frequency score × 1.4 + long pants frequency score × 1.8)/3+5.7

In this formula, 5.7 was included as a baseline clothing score, 0.4 was a weight for average head cover, 1.4 was a weight for average long–sleeved shirt cover and 1.8 was a weight for average long pants cover. In order to standardise the score, the total of these components was divided by three. The total score was standardised to a theoretical range of 0 to 10 indicating 0 to 100% of the body surface area for better interpretation. As no one was likely to be 100% covered by clothing, the actual total score ranged from 5.7 to 9.3 in this formula, with higher scores indicating that a larger body surface area was covered by clothing. For example, a value of 6.0 meant 60% of the body surface area was covered by clothing.

3.8.1.3 Sunscreen use

Five questions were administrated regarding sunscreen use (see Appendix A, a copy of Survey One at questions 65-69). They were:

- Have you used sunscreen in the past month? Yes/No

- What is the sun protection factor (SPF) of the sunscreen that you have used most often, including sunscreen, daily moisturizer and make-up (for example, SPF 30+)? Open-ended question.
- Over the past month, on average, how often have you used any of the products described in the above questions? Every day/ 5-7 days a week/ 3-4 days a week/ 1-2 days a week/ less than once a week.
- On days that you have used sunscreen in the past month, how often did you apply it throughout the day? Open-ended question.
- Where do you usually apply sunscreen when you have used it over the past month? Nine parts of the body were listed: face, neck, trunk, upper arms, forearms, hands, thighs, lower legs and feet. Two options for each body part: Yes/No.

These questions were used to describe the sunscreen use details of the participants in the previous month. For simplification, only the first question was applied when conducting bivariate and further analysis in this thesis.

3.8.1.4 Dietary vitamin D intake (μg/day)

The main food items contributing to dietary vitamin D intake were oily fish (salmon, tuna, sardines, anchovies and mackerel), margarine, butter, eggs, beef and liver. The vitamin D intake from food for each woman was estimated by summing up the vitamin D contribution of each of these foods. Intake was calculated by multiplying the amount of vitamin D in a serving size of those food items by the frequency of consumption.

Participants were asked about their consumption of foods listed above in the previous month: that is "frequency" and "time period". The time periods were recoded as follows: "Never" = 0, "Day" = 30.5, "Week" = 4.2857, "Month" = 1. Then the intake of every food per month was calculated by frequency × recoded time period.

According to the NUTTAB 2010 - Vitamin D File (FSANZ), the food quantity was recorded into vitamin D micrograms per month. The vitamin D amounts in different foods used are: salmon average = 5.775μg per 100 grams, sardine average = 4.033μg per 100 grams, tuna average = 1.625μg per 100 grams, margarine average = 7.5μg per 100 grams, egg average = 0.47778μg each, beef average = 0.0182μg per 100 grams and butter = 0µg per 100 grams. Mackerel was not on the list, so herring was used as a substitute, with the vitamin D in herring being 13µg per 100 grams. No data could be found in this list for vitamin D as a nutrient in anchovies, either in other where, so this was not used in calculating vitamin D. Meanwhile, the vitamin D content of liver was not on the list, however, only seven women stated that they had consumed small portions of liver in the previous month. Finally, adding everything together, an approximation of dietary intake of vitamin D in the past month (µg per month) was made, then by dividing by 30.5, an average daily vitamin D intake (µg per day) from food was obtained.

3.8.1.5 Vitamin D supplements (IU per day)

According to questions on supplements and supplement charts (see Appendix A, a copy of Survey One at questions 65-69), the everyday dose of vitamin D from supplements was calculated for every participant in the past month, using IU per day.

3.8.2 Independent Variables

3.8.2.1 Demographic characteristics

Questions sought information about demographic characteristics, including date of birth, country of birth, state or territory of living, parents' ethnic origin, educational level, occupation, current employment status, smoking, alcohol consumption, general health, skin colour and skin burn capacity (see Appendix A, a copy of Survey One, Parts A and B).

3.8.2.2 Obstetrical variables

Questions also sought information about obstetrical variables, including estimated date of delivery, and then current gestational week, pre-pregnancy weight, height, gravidity and parity (see Appendix A, a copy of Survey One at questions 31-37).

Pre-pregnancy body mass index (BMI) was calculated using the formula: BMI = mass (kg)/height^2 (m^2) (Eknoyan, 2008).

3.8.2.3 Knowledge and Attitudes

(a) Knowledge

Four open-ended questions asked about the participants' knowledge of vitamin D (see Appendix A, a copy of Survey One at questions 92-95). These were as follows:

- "To the best of your knowledge, what are some of the health problems people may develop if they don't get enough vitamin D? You can write down up to 5 health problems below."
- "To the best of your knowledge, what symptoms and signs might suggest you are not getting enough vitamin D? You can write down up to 5 health problems below."
- "To the best of your knowledge, what things can people do to ensure they get enough vitamin D? You can write down up to 5 health problems below."
- "Which of the theses strategies for ensuring adequate vitamin D levels do you think would be the main one?"

When performing bivariate and further analyses, a total score of knowledge was applied. Since *Question* "Which of these strategies for ensuring adequate vitamin D levels do you think would be the main one?" is a sub-question of *Question* "To the best of your knowledge, what things can people do to ensure they get enough vitamin D?" it was not used when scoring. For the first two questions, participants were asked to write down up to five answers, thus, one point was given to every correct answer. The theoretical range of the score for each question was from zero (don't know/not sure/give unrelated answer) to five(give five correct answers). For the third question, answers were generalized into three strategies firstly: sun exposure, diet and supplements. Any answers referring to any of the three aspects were treated as correct answers, and one point was assigned for each and every strategy. The theoretical range of the score for this question was from zero (don't know/not sure/give unrelated answer) to three (all three strategies given). Finally, all three knowledge questions' scores were added together, making a total ‘knowledge of vitamin D’ score ranging from 0 to 13 theoretically. Higher scores meant higher levels of vitamin D knowledge.

(b) Attitudes

Three statements were given to seek the attitudes to vitamin D and sun exposure of every participant. These ranged from “Strongly agree”, “Agree”, “Neither agree nor disagree”, “Disagree”, “Strongly disagree” to “Can’t say” (see Appendix A, a copy of Survey One at question 96). The three statements were:

- “I need to spend more time in the sun during summer to get enough vitamin D to be healthy.”
- “I worry about getting enough vitamin D.”
- “It is more important to stay out of sun than it is to get enough vitamin D.”

When performing bivariate and further analyses, a total score for attitude was applied. For better interpretation, the two opinions “Neither agree nor disagree” and “Can’t say” were collapsed together as “Neither agree nor disagree”. Thus, there was a 5-point Likert scale. As can be seen, the first two statements have a positive attitude toward vitamin D, while the third statement shows a negative attitude toward vitamin D. Therefore, for the first two questions, the answer ranged from “Strongly disagree”=1, “Disagree”=2, “Neither agree nor disagree”=3, “Agree”= 4 to “Strongly agree”=5. For the third question, the answer ranged from “Strongly disagree”=5, “Disagree”=4, “Neither agree nor disagree”=3, “Agree”=2 to “Strongly agree”=1. Finally, all three attitude statements’ scores were added together, making a total ‘attitude toward vitamin D’ score, ranging from 3 to 15, theoretically. Higher scores represented more positive attitudes toward vitamin D.

3.8.3 Pregnancy Outcome Variables

Pregnancy outcomes were gathered in the follow-up survey (see Appendix B for a copy of Survey Two), including the type of delivery (vaginal or caesarean), weight gain in during pregnancy, gestational diabetes (Yes/No), preeclampsia (Yes/No), gestational age, new baby’s sex, birth weight, birth length, head circumference at birth, Apgar score at one minute and Apgar score at five minutes.

3.9 DATA ANALYSIS

Data from the surveys were directly exported to a statistical software package, IBM SPSS statistics 19 (SPSS Inc., Chicago, IL, USA) for coding, cleaning and subsequent data analysis. The direct transfer of data to SPSS avoided human error in data entry.

3.9.1 Data Coding

Each subject was allocated an identity (ID) number in order to maintain confidentiality. Individual responses for categorical items from Part A to Part D were coded for subsequent data analysis.

Refinement or collapsing of variables was conducted, due to limited numbers of participants in some categories or to generate more meaningful categories for analysis.

Age was collapsed from continuous years of age into three categories: < 30 years (a relatively young age), 30 to 34 years (the most popular fertility age), and ≥ 35 years (a relatively old age).

For the question of country of birth, other countries outside of Australia were recorded as “Non-Australia”.

For the question identifying the state or territory of residence, the total eight states or territories were collapsed to two categories: Northern Australia and Southern Australia, according to the latitude, >26°S or <26°S. Consequently, participants were categorized into those living in relatively more sunshine and warm areas—Northern Australia (>26°S), and those living in relatively less sunshine and cold areas—Southern Australia (<26°S).

Due to the large number of participants who had either a bachelor’s degree or postgraduate degree, the education background “Did not complete primary school”, “primary school”, “some high school”, “year 12 senior certificate (or HSC)”, “trade/apprenticeship” and “certificate or diploma” were collapsed into one category, “Under university”.

For the question that assessed participants' current employment status, the answer options "unemployed", "home duties", "student", "on maternity leave", "sole parent pension", "disability pension" and "retired" were collapsed to form one category: "Other".

For the skin colour question, "olive" and "medium" were collapsed into one group.

The question assessing skin burn capacity when in the sun in the middle of the day without sunscreen, the answers "burn after 1 – 2 hours" and "burn after more than 2 hours" were collapsed into one category, "burn after 1 hour".

The season at enrolment was obtained through submitting date: winter included June, July and August, spring included September, October and November, and summer included December, January and February. There was no summer data due to the limited time of PhD candidature. Due to unbalanced numbers of participants in each season, spring and summer were collapsed into one group, in order to compare those who completed the survey during winter.

BMI calculated by weight and height was collapsed from a continuous valuable into two categories: < 25 and ≥ 25.

A trimester was calculated by weeks of pregnancy: 1-12 weeks was "first trimester", 13-27 weeks was "second trimester", and "28 weeks and over" was "third trimester".

Gravidity was collapsed into three categories: 1, 2 and ≥ 3.

Parity was collapsed into two categories: 0 and ≥ 1.

Finally, miscarriage history was calculated from gravidity and parity, and was collapsed into two categories: 0 and ≥ 1.

3.9.2 Data Cleaning

To eliminate errors that may have occurred during data collection and coding stages, data cleaning was commenced once the data coding was completed. First, each of the variables was screened to check whether there was a lack or excess of data, outliers or inconsistencies, and strange patterns. If errors occurred, then the value would be corrected or deleted after checking the questionnaire.

3.9.2.1 Management of missing data

There were mainly four types of data considered as ‘missing’. The first, and most common in this study, was the case in which no data were recorded in some questions. This type of missing data appeared as a system missing value in the SPSS table. The second type of missing value was information about something that was not applicable to the participants. For example, having a medication and supplementation chart for participants who were not on medication and supplementation. They did not take any medicine or supplements, therefore did not answer the question. The third type of missing value was when the answers appeared to be incorrect (for example, the date of birth was reported as being 01/01/1890), this value was considered as missing. The fourth type of missing value occurred when information was not specified. There may have been two answers for one question and the two answers were the opposite of each other. All of these types of missing values were identified in the statistical analyses. A "missing" value is assigned an extreme numeric value--either very high or very low. Hence, values coded as missing can be compared to other values, or vice versa.

Descriptive analysis was conducted and the percentage of missing values was reported for each of the variables.

3.9.2.2 Outliers

An outlier is a situation with an extreme value on one variable (a univariate outlier) or more variables (multivariate outlier) such that it distorts the statistics. Graphical methods were suitable for finding univariate outliers. Histograms and box plots were useful for checking outliers.

3.9.3 Data Analysis Plan

Data analysis was conducted using SPSS 19 software. A significance level of 0.05 was used to indicate statistically significant associations. The following strategies were undertaken during the subsequent analysis.

3.9.3.1 Descriptive analysis

Descriptive statistics were undertaken to give summary descriptions for core variables and other measured variables, which were calculated in terms of percentage, mean, standard deviation (SD), median, range, 95% Confidence Interval (95% CI), frequency and percentage. For continuous variables, data were presented as mean (SD) when normally distributed, and median with range when distributed as skewed. Frequency and percentage were used for categorical variables.

3.9.3.2 Normality

In most tests of the relationship between variables, especially continuous variables, the assumption of multivariate normality needed to be considered. Before the analysis of each research question, normality checking was considered for the studied variables. Normality of variables was assessed by statistical and graphical methods. Skewness and kurtosis of the variable were considered in the normality analysis. Frequency histograms were used to assess the normal distribution for the analysed variables. In this thesis, outdoor time and UV adjusted outdoor time were distributed as skewed, but were normally distributed after logarithmical transformation.

3.9.3.3 Bivariate analysis

To identify factors influencing the vitamin D related behaviours of pregnant women, bivariate analysis was conducted to examine the differences between groups.

As described in the data coding section, all continuous demographic and obstetrical variables were categorised into groups. An independent samples t test was conducted to explore the relationships between each continuous outcome variable and the dichotomous independent variables. A one-way ANOVA test was applied in order to explore the relationships between each continuous outcome variable and the categorical independent variables except dichotomous independent variables. Assumptions of the independent samples t test and ANOVA test included: Cases representing random samples from the populations and the scores of the test variable were independent of each other; sample sizes were large and approximately equal (>15 cases per group); dependent variables must have been normally distributed in all groups; and there must have been approximately equal variance across all groups. As mentioned at the last section, only UV adjusted outdoor time was skewed and was logarithmically transformed.

A chi-square test was used to explore the relationships between each categorical outcome variable and the categorical independent variables. Assumptions of the chi-square test included a random sample, independence within samples and mutual independence between samples, two categorical variables with two or more categories in each group and five more expected frequencies in any cell. When the lowest expected frequency in a cell was less than five in a 2 × 2 table, Fisher's exact probability test was reported.

Bivariate correlations were conducted for continuous independent variables (knowledge score and attitude score as shown in this thesis) correlating with dependent variables, either continual or categorical. A Pearson correlation was used when both independent and dependent variables were normally distributed, continuous data. Point biserial correlation was applied when independent variables were continuous and also normally distributed, but dependent variables were categorical.

3.9.3.4 Multivariate analysis

After bivariate analysis, a general linear model for continuous dependent variables and binary logistic regression for dichotomous dependent variables was conducted to control the covariates of each outcome variable. The independent variables met the criteria below were entered in the model as covariates: Significant associations at the bivariate level ($p<0.05$); displayed trends (set as $p<0.2$); or known as confounders from previous literature.

3.10 ETHICAL CONSIDERATIONS

This study used pregnant women as participants, therefore, care was required in the planning and conduct of this study to maximise its benefits and to minimise its risks. Approval for this study was granted from the QUT Human Research Ethics Committees, and the Ethics Approval number is 1000000151.

All participants were fully informed about the project before participation. The PIS clearly outlined the purpose of the project, the potential benefits of the project, the possible risks of participation, and the requirements of participants.

All participation was on a voluntary and confidential basis. As it was infeasible to obtain a participant's written consent to participate in this project, every participant was asked to mark a check box, "I ACCEPT", on the Consent Form page after reading the PIS and Consent Form information. All participants were allowed to withdraw at any time and were advised that this would not impact on her current or future relationship with QUT in any way.

Every precaution was taken to protect confidentiality. Electronic files are stored on a password-protected computer and backup copies of these files are kept on a secure drive in the QUT IT system. For the hard copies, all data were kept at QUT in a locked storage cabinet. Access to these data is limited to the researcher and supervision team. Participants were also advised that any reports or publications would not identify them.

Chapter 4: Results

PART A: Description of Sample Characteristics

4.1 DEMOGRAPHIC CHARACTERISTICS

The demographic characteristics of participants are shown in Table 4.1.

There were a total of 246 pregnant women taking part in the baseline survey, of which 81 did not complete the entire questionnaire. Among the 165 who completed the baseline survey, only one was living in New Zealand, all others were living in Australia. This study aimed to investigate women in Australia, thus, a total of 164 respondents were included in this study.

The age of the participants ranged from 22 to 42 years, with 31 ± 4.1 years of the mean age. Nearly half (41.5%)of the participants were between 30 and 34 years old, while 34.5% of women were under 30 years old and 23.2% were 35 years and older.

Participants were mainly (65.2%) recruited during winter (June, July and August), while 29.9% were in spring (September, October and November), and only eight participants were recruited in summer (December, January and February).

Most participants (59.1%) were from Queensland, but 12.8% and 12.2% were living in Victoria and New South Wales respectively, and 9.1% were living in South Australia. The remaining participants came from the other four states and territories: 2.4% from the Australian Capital Territory, both 1.8% from Western Australia and Tasmania, as well as 0.6% from the Northern Territory.

Duration at their current residence ranged from one year to 42 years: 61% of participants had been living in their current residence for over 20 years, while 28% had lived there less than 10 years.

Those from 'Northern Australia' totalled 59.8%, that is, above 26°S, an area with relatively more sunshine and warmth. The rest (40.2%) were from 'Southern Australia', living at 26°S and below, an area of relatively less sunshine and colder.

Approximately 82% of the participants were born in Australia, but 4.3% and 4.9% were born in New Zealand and the United Kingdom, respectively. All other countries accounted for 9.1%, most commonly the USA, Germany and China. Among the total of 31 participants who were not Australian born, 13 of them arrived in Australia before the year 2000.

Over 60% of the participants reported that their natural skin colour was “fair”, while 25% and 12% had “medium” and “olive” complexions, respectively. No one recorded “black” as their complexion in this population.

The majority (63.4%) of women’s skin was reported as being easily burnt in the sun (burn within 1 hour) when sitting in the sun in the middle of the day for the first time in summer without sunscreen. This included 34.1% who burnt within half an hour and 29.3% who burnt in half to one hour. There were no participants who indicated that they never burned. Similar proportions (45.7% and 44.5% respectively) were reported on the question of skin “burn then peel” or “burn then tan”. Only 9.8% stated that they “tan only” when going out in the sun for one hour in the middle of the day for the first time in summer without sunscreen. After a two-week holiday at the end of summer, 7.9% felt that they had a “dark tan” on their skin, while 36% and 37.8% reported themselves as having a “medium tan” and “light tan”, respectively. There were 18.3% participants who declared “practically no tan”.

All participants completed primary school, and over 90% received a higher educational level, including 22% at the level of certificate or diploma, 43.9% with abachelor’s degree and 25.6% with a postgraduate degree. Nearly 90% of the participants stated that their occupation sun exposure status was “mainly indoors”, while about 10% said “half indoors and half outdoors”. Only one reported that she worked “mainly outdoors”. More than 75% of pregnant women were still working at the time of enrolment, either “full-time” (51.8%) or “part-time” (23.2%). For the rest women, 17.1% were doing “home duties”, 4.3% were “students”, and 1.8% were on “maternity leave”.

Almost all pregnant women (94.5%) rated themselves as being in “good” or even above (“very good” or “excellent”) health generally, six stated that they were in “fair” health, and three reported being in “poor” or “very poor” condition. Four participants had been previously diagnosed with cancer: three in 2010 and one in 2011 respectively, including three melanomas and one other skin cancer. Eleven participants had been told they had high blood pressure, one reported high cholesterol and one reported osteopaenia. Within these, only two women were taking medicines to control high blood pressure at the time of enrolment. Among those in a "fair" health condition, one pregnant woman noted high blood pressure and being on medication. The reasons for the self-assessment of "fair" or worse health were not given for the other eight women.

With regard to smoking and alcohol consumption, 30% had been regular smokers (a regular smoker was defined as being one who smoked daily, or at least seven times per week, for at least three months.), however, none recorded themselves as "a current smoker" during this pregnancy. Non-alcohol drinkers represented 86% of women, while 11% took three or fewer standard drinks (one standard drink= a glass of wine, middy of beer or nip of spirits), and, 3% of women had more than three drinks every week.

Table 4.1 Demographic characteristics for sample (N=164)

Variable	N (%)	Variable	N (%)
Country of birth		***Age group (years)***	
Australia	134(81.7)	<30	58(35.4)
New Zealand	7(4.3)	30-34	68(41.5)
UK	8(4.9)	≥35	38(23.2)
Other	15(9.1)	***Season of evaluation***	
State/territory		Winter	107(65.2)
Queensland	97(59.1)	Spring	49(29.9)
New South Wales	20(12.2)	Summer	8(4.9)
Victoria	21(12.8)	***Ever smoker***	
Tasmania	3(1.8)	Yes	48(29.3)
South Australia	15(9.1)	No	116(70.7)
Western Australia	3(1.8)	***Current smoking***	
ACT	4(2.4)	Yes	0(0.0)
Northern Territory	1(0.6)	No	164(100.0)
Educational level		***Alcoholic drinks***†	
Did not complete primary school	0(0.0)	0	141(86.0)
Primary school	0(0.0)	3 and less	18(11.0)

Variable	N (%)	Variable	N (%)
Some high school	3(1.8)	Above 3	5(3.0)
Year 12 senior certificate(or HSC)	10(6.1)	***General health***	
Trade/Apprenticeship	1(0.6)	Excellent	31(18.9)
Certificate or Diploma	36(22.0)	Very good	74(45.1)
Bachelor's degree	72(43.9)	Good	50(30.5)
Postgraduate degree	42(25.6)	Fair	6(3.7)
Occupation		Poor	2(1.2)
Manager or administrator	51(31.3)	Very poor	1(0.6)
Professional	78(47.6)	***Cancer***	
Salesperson/personal service worker	16(9.8)	Yes	4(2.4)
Clerk	15(9.1)	No	160(97.6)
Labourer or related worker	2(1.2)	***Health Condition***	
Plant or machine operator or driver	1(0.6)	High blood pressure	11(6.7)
Member of defence	1(0.6)	High cholesterol	1(0.6)
Current employment		Osteomelacia	0(0.0)
Full-time work	85(51.8)	Osteopaenia	1(0.6)
Part-time work	38(23.2)	Osteoporosis	0(0.0)
Other	41(25.0)	None of above conditions	151(92.1)
Occupational sun exposure status		***Mother's ethnicity***	
Mainly indoors	143(87.2)	Australian non-indigenous	71(43.3)
Half indoors and half outdoors	20(12.2)	English	47(28.7)
Mainly outdoors	1(0.6)	Irish	8(4.9)
Natural skin colour		Chinese	7(4.3)
Fair	104(63.4)	German	5(3.0)
Medium	60(36.6)	Other	26(15.8)
Olive	19(11.6)	***Father's ethnicity***	
Dark/black	0(0.0)	Australian non-indigenous	72(43.9)
Skin burn capacity		English	39(23.8)
Burn within ½ hour	56(34.1)	Irish	10(6.1)
Burn after ½ - 1 hour	48(29.3)	Chinese	6(3.7)
Burn after 1 hour	60(36.6)	German	4(2.4)
		Other	33(20.1)

† denotes standard drinks for every week

4.2 OBSTETRICAL VARIABLES

The obstetrical variables of the participants in this study are shown in Table 4.2.

The weeks of gestation of these women at enrolment ranged from 13 weeks to 39 weeks, and the mean week of gestation was 21.9 ± 6.8 weeks, while 21 weeks was the median week of pregnancy. Among these, 127(77.4%) were in the second trimester while 37(22.6%) were in the third trimester. There were no participants in the first trimester, because one of the criteria of this study was to be at least three months pregnant due to the consideration of decreasing the possibility of miscarriage to increase the follow-up ratio. The times of being pregnant varied from one to seven times, of which 43.3% women reported that the present pregnancy was their first pregnancy, about 30% were the second, and 27.4% had been pregnant more than three times. Of these pregnant women, 53% stated that they had never given birth before, while over 30% and more than 10% stated that they had previously had one or two labour experiences respectively. Only 3% had three or more experiences of labour before. Therefore, according their gravidity and parity reports, it was calculated that approximately 25% of women had had at least once experience of miscarriage.

The body mass index (BMI) was calculated by weight (kg) divided by height^2 (m^2) and used to stratify participants into underweight (< 18.5), normal (18.5-24.9), overweight (25-29.9), obese (30-39.9) and morbidly obese (≥ 40) categories, according to the WHO classification guidelines of body fatness. The BMI calculated here was the pre-pregnancy BMI for women. The median BMI of all participants was 23.7 (range 16.1 to 51.3). About half of the women (56.7%) were in the 'normal' range, but about 5% were 'underweight' and 38.4% were either 'overweight' or 'obese'. There were four participants who were in the 'morbidly obese' (BMI ≥ 40) category.

Table 4.2 Obstetrical variables for sample (N=164)

Variable	N (%)	Variable	N (%)
Gravidity		***Trimester***	
1	71(43.3)	Second	127(77.4)

2	48(29.3)	Third	37(22.6)
≥3	45(27.4)	***Pre-pregnancy BMI***	
Parity		<18.5(underweight)	8(4.9)
0	87(53.0)	18.5-24.9(normal)	93(56.7)
≥1	77(47.0)	25-29.9(overweight)	44(26.8)
Miscarriage history		30-39.9(obese)	15(9.2)
0	122(74.4)	≥40(morbidly obese)	4(2.4)
≥1	42(25.6)		

4.3 KNOWLEDGE AND ATTITUDES TO VITAMIN D

4.3.1 Knowledge

The knowledge of vitamin D was assessed by asking four open-ended questions.

4.3.1.1 Knowledge of health problems if vitamin D deficient

The majority of the participants (73.2%) indicated that they had some knowledge of health problems if they had not had enough vitamin D, including 64.6% who could cite some bone-related health problems and 29.9% who could cite some other non-bone-related health problems. There were still 26.8% reporting “unknown” or “not sure” or giving totally unrelated answers.

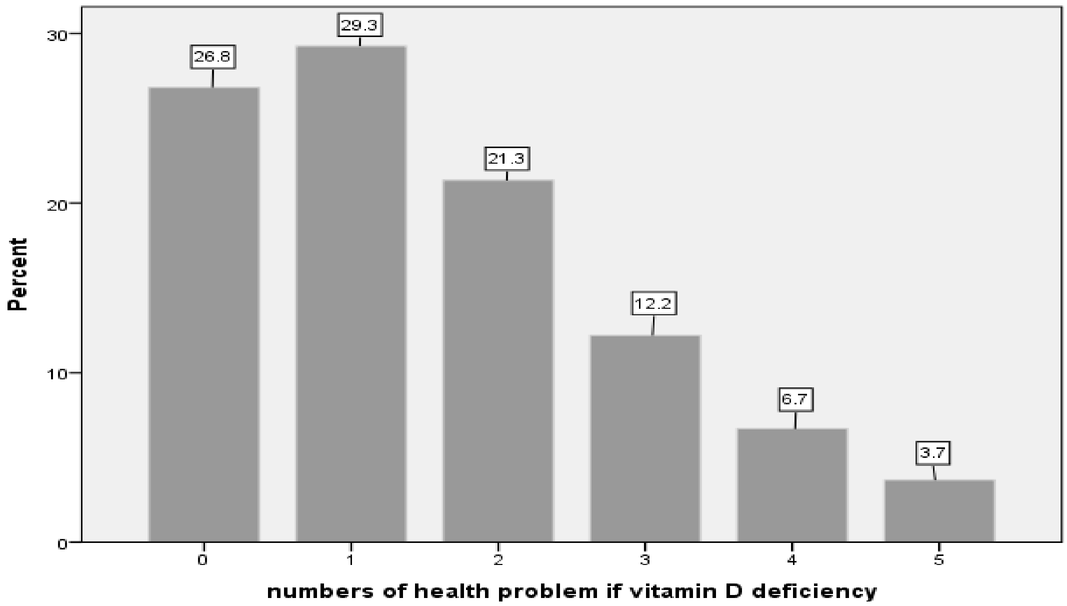
Among the 106 pregnant women who reported knowledge of some bone health problems, 26.4% stated general bone issues, for example bone problems, weak bones, bone loss, and decrease in bone density. There were 37.7% and 47.2% participants who referred to rickets and osteoporosis, respectively, in their answers. Also, 12.3% of women mentioned brittle bones and 17.9% referred to calcium absorption problems. Very few (0.5%) women answered with osteopaenia or osteomalacia.

With regard to the knowledge of non-bone health problems related to vitamin D deficiency, depression was the most popular answer (44.9%), followed by weakened immune systems (18.4%), heart disease (16.3%), cancer (14.3%), hypertension (10.2%) and diabetes (6.1%). Only two women mentioned muscle weakness and one woman reported influenza.

Table4.3 Knowledge of health problems among 164 participants

Knowledge of health problems if vitamin D deficient	N (%)
Knowledge of any health problems	**120(73.2%)**
a. bone health problems	106 (64.6%)
general bone issue†	*28 (26.4%)*
rickets†	*40 (37.7%)*
osteoporosis†	*50 (47.2%)*
brittle bones†	*13 (12.3%)*
calcium absorption problem†	*19 (17.9%)*
b. non-bone health problems	49 (29.9%)
depression‡	*22 (44.9%)*
weakened immune system‡	*9 (18.4%)*
heart disease‡	*8 (16.3%)*
cancer‡	*7 (14.3%)*
hypertension‡	*5 (10.2%)*
Unknown/Not sure/Unrelated	**44 (26.8%)**

†percentages calculated of 106 participants, ‡percentages calculated of 49 participants. There is an overlap in knowledge of a and b.



0: don't know/give totally wrong health problems; 1: give one right health problem; 2: give two right health problems; 3: give three right health problems; 4: give four right health problems; 5: give five right health problems

Figure 4.1 The distribution of women in health problem knowledge

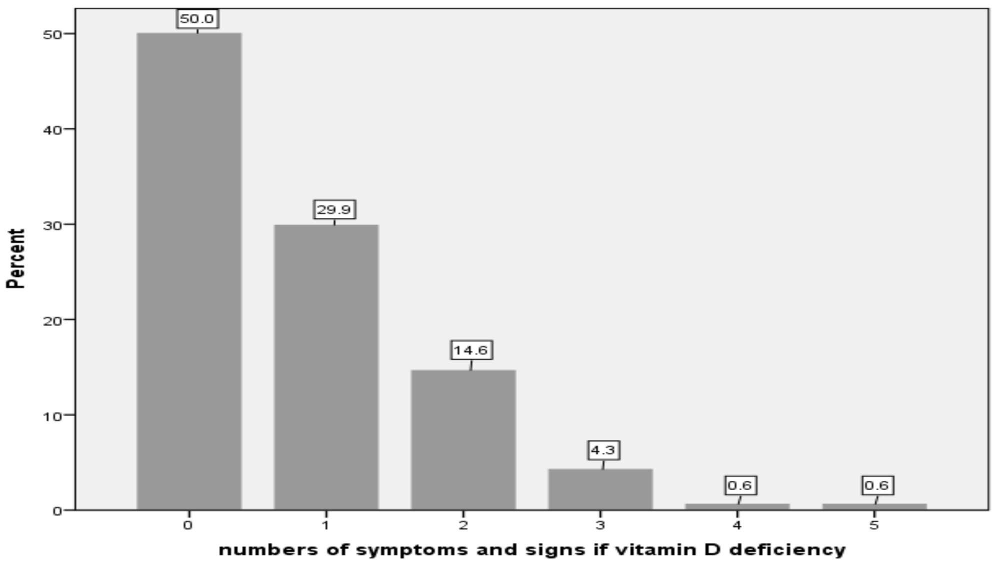
4.3.1.2 *Knowledge of symptoms and signs if vitamin D deficient*

Answers that were given by 50% of the participants included either “unknown” or “not sure”, or they were totally unrelated, such as dehydrated skin or yellowing of the skin. In the another half proportion who reported at least one of symptoms or signs of vitamin D deficiency, most of them (70.7%) stated a generalized weakness, for example, tiredness, lethargy, fatigue, dizziness or frequent illness. Some (15.9%) women answered with mood change, including depression. Many (57.3%) pregnant women knew at least one of the bone-related problem health symptoms or signs, including rickets, osteoporosis, aching joints, fractures orhypocalcemia, and 13.4% indicated muscle pain or weakness. There were also three answers relating to dental problems.

Table 4.4 Knowledge of symptoms and signs among 164 participants

Knowledge of symptoms and signs of vitamin D deficiency	N (%)
Know about the symptoms and signs	**82 (50.0%)**
generalized weakness†	*58 (70.7%)*
mood change†	*13 (15.9%)*
bone-related†	*50 (61.0%)*
muscle pain/weakness†	*11 (13.4%)*
Unknown/Not sure/Unrelated	**82 (50.0%)**

†percentages calculated of 82 participants who knew about symptoms and signs of vitamin D deficiency



0: don’t know/give totally wrong symptoms/signs; 1: give one right symptom/sign; 2: give two right symptoms/signs; 3: give three right symptoms/signs; 4: give four right symptoms/signs; 5: give five right symptoms/signs

Figure 4.2 The distribution of women in symptom and sign knowledge

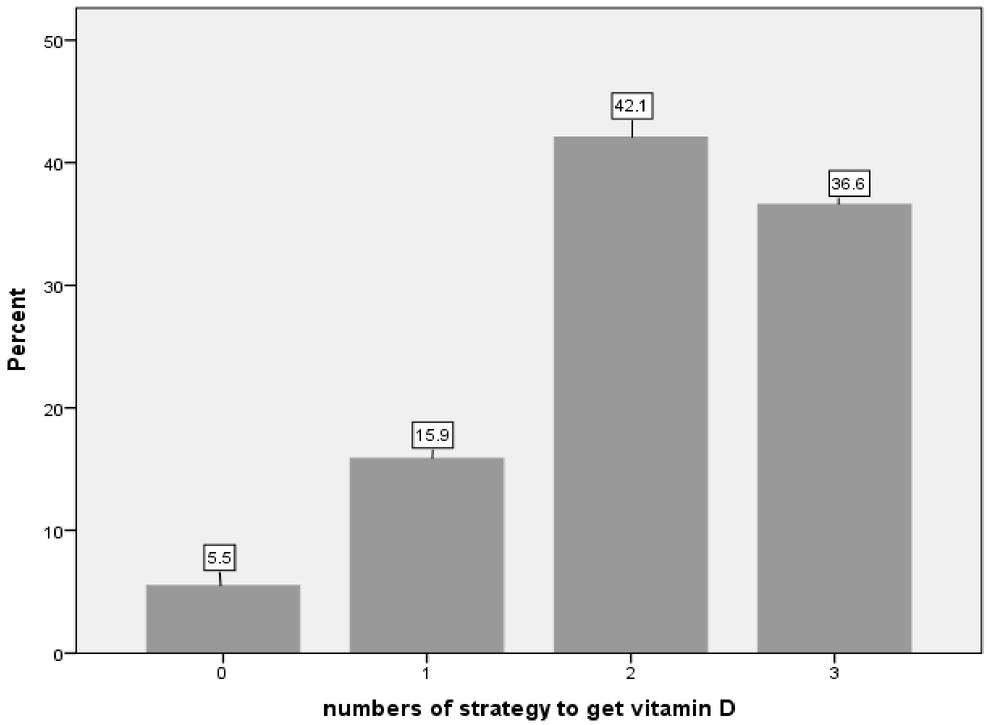
4.3.1.3 Knowledge of how to get vitamin D

Only 5.5% woman reported “unknown” for this question. All positive answers were generalized into three strategies: sun exposure, diet and supplementation. Among the rest, 155 women stated at least one strategy to get vitamin D, 39.4% of women combined all three strategies to get vitamin D, 43.9% selected any two of the strategies and 16.7% chose any one.

Table 4.5 Knowledge of how to get vitamin D among 164 participants

Knowledge of how to get vitamin D	**N (%)**
Know about how to get vitamin D	**155 (94.5%)**
only sun exposure†	*23 (14.8%)*
only diet†	*1 (0.6%)*
only supplementation†	*2 (1.3%)*
any two of the three strategies above†	*68 (43.9%)*
all of the three strategies above†	*61 (39.4%)*
Unknown	**9 (5.5%)**

†percentages calculated of 155 participants who knew about how to get vitamin D



0: don’t know/give totally wrong strategies; 1: give one right strategy; 2: give two right strategies; 3: give three right strategies

Figure 4.3 The distribution of women in strategy knowledge

4.3.1.4 Knowledge of main strategy to get vitamin D

To answer this question, 10.4% of women reported "unknown". Not surprisingly, the majority of women (64.6%) chose "sun exposure" as the main strategy, while 9.8% and 7.8% selected supplementation and diet, respectively, as the main strategy. There were also some women (7.3%) stating a combination of the strategies as their choice.

Table 4.6 Knowledge of main strategy to get vitamin D among 164 participants

Knowledge of main strategy to get vitamin D	N (%)
Best strategy to get vitamin D	**147 (89.6%)**
sun exposure†	*106 (72.1%)*
diet†	*13 (8.8%)*
supplementation†	*16 (10.9%)*
combination either two or three of above†	*12 (8.2%)*
Unknown	**17 (10.4%)**

†percentages calculated of 147 participants

4.3.2 Attitudes

The attitudes toward vitamin D were assessed by three Likert scale questions.

As can be seen in Table 4.7, 39% of pregnant women agreed or strongly agreed with the statement "I need to spend more time in the sun during summer to get enough vitamin D to be healthy". However, 42.7% disagreed or strongly disagreed with this statement, and the rest (21.3%) stood neutrally. When mentioning "I worry about getting enough vitamin D", more women disagreed or strongly disagreed than those women who agreed or strongly agreed, with percentages of 43.3% versus 39%, respectively. There were also 17.7% who were neither agreeable nor disagreeable, including 1.2% who chose "can't say". Nearly one third (32.3%) kept neutral on the statement of "It is more important to stay out of the sun than it is to get enough vitamin D". Over half of the women (51.2%) chose "disagree" or "strongly disagree", while only 16.4% chose "agree" or "strongly agree".

Table 4.7 Attitudes toward vitamin D of 164 participants N (%)

ATTITUDES	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree	Can't say
Attitude 1	10(6.1%)	49(29.9%)	35(21.3%)	54(32.9%)	16(9.8%)	0(0.0%)
Attitude 2	10(6.1%)	54(32.9%)	27(16.5%)	52(31.7%)	19(11.6%)	2(1.2%)
Attitude 3	5(3.0%)	22(13.4%)	53(32.3%)	66(40.2%)	18(11.0%)	0(0.0%)

Attitude 1: I need to spend more time in the sun during summer to get enough vitamin D to be healthy.
Attitude 2: I worry about getting enough vitamin D.
Attitude 3: It is more important to stay out of the sun than it is to get enough vitamin D.

Generally, for these three statements, approximately 40% were on the "agree" side, another 40% were on the "disagree" side, and the rest, 20%, stood neutral.

PART B: Vitamin D Related Behaviours

4.4 SUN EXPOSURE AND PROTECTIVE BEHAVIOURS

4.4.1 Outdoor Time

4.4.1.1 Pattern of outdoor time

A total outdoor time everyday on average is summarized below in minutes per day.

Typically, the time spent outside ranged from zero minutes per day to 291 minutes per day by participating the month previous completing the questionnaire. The mean outdoor time was 86.35 minutes per day (SD=58.86, 95% CI: 77.28-95.43), with a median outdoor time of 74 minutes per day.

Generally, UV radiation levels are highest around the middle of the day, 10 am to 2 pm, adapted from Cancer Council NSW. Here, one day was divided into three time periods: before 10 am, between 10 am and 2 pm, and after 2 pm. Average outdoor time (minutes per hour) was calculated using total outdoor time during the time period (minutes) divided by hours at that time period (hours).

(a) Three different time periods

As the average outdoor time data were not normally distributed, a natural logarithmic transformation was completed, based on the constant e (2.72) when making comparison, after which these data were considered as normally distributed data.

A one-way, between-groups ANOVA was conducted to explore the impact of the time period for every hour of outdoor time. On weekdays, there was a statistically significant difference at the $p<0.05$ level in every hour of outdoor time for the three different time periods: $F=3.093$, $p=0.046$. Posthoc comparisons using an LSD test indicated that the mean min/hour of outdoor time before 10 am (mean= 2.90 minutes/hour, 95% CI: 2.54-3.32) was significantly less than min/hour of outdoor time after 2 pm (mean=3.79 minutes/hour, 95% CI: 3.26-4.40, p=0.015), while no statistical significance was found for min/hour of outdoor time for either the “before 10am” period and the “from 10 am to 2 pm” period (mean=3.48 minutes/hour, 95% CI:

2.74-4.13, p=0.096), or between the time periods "from 10 am to 2 pm" and "after 2 pm" (p=0.444). The participants spent longer for min/hour of outdoor time "after 2 pm" than "before 10 am".

On weekends, there was a total, statistically significant difference in min/hour of outdoor time among the three time period groups: F=14.572, p=0.000. Posthoc comparisons using an LSD test indicated that min/hour of outdoor time "before 10 am" (mean=3.75 minutes/hour, 95% CI: 3.17-4.44) was significantly less than min/hour of outdoor time "between 10 am and 2 pm" (mean=7.31 minutes/hour, 95% CI: 6.14-8.71, P=0.000), and was also less than min/hour of outdoor time "after 2 pm" (mean=5.13 minutes/hour, 95% CI: 4.31-6.11, p=0.012). Also, min/hour of outdoor time "between 10 am and 2 pm" was significantly more than "after 2 pm" (p=0.004). The pregnant women stayed outside longest for every hour "between 10 am and 2 pm". Every hour of time spent outdoors "after 2 pm" took the second place, while "before 10 am", women spent the least time outdoors per hour.

Table 4.8 Comparison of outdoor time per hour at three time periods (minute/hour)

Outdoor time	Mean[1]	95% CI[1] (LB-UB)	F value	Mean[2](min/hour)	95% CI[2] (LB-UB)
Weekdays			**3.093***		
before 10 am	1.07[a]	0.93-1.20		2.90	2.54-3.32
10 am – 2 pm	1.25[a,b]	1.08-1.42		3.48	2.74-4.13
after 2 pm	1.33[b]	1.18-1.48		3.79	3.26-4.40
Weekends			**14.572***		
before 10 am	1.32[a]	1.15-1.49		3.75	3.17-4.44
10 am – 2 pm	1.99[b]	1.81-2.16		7.31	6.14-8.71
after 2 pm	1.64[c]	1.46-1.81		5.13	4.31-6.11

Note: 1 denotes ln(time), 2 denotes values anti-natural logarithmic transformed from 1. * denotes p value < 0.05. a,b,c denotes statistical significance from each other group underlying one category. CI denotes Confidence Interval, LB denotes Lower Bound, UB denotes Upper Bound

(b) Weekdays and weekends

An independent samples t test was conducted to compare outdoor time on weekdays and on weekends. Overall, pregnant women spent less time outside every day on weekdays than on weekends for the whole day (52.46 minutes/day vs 89.12 minutes/day, p=0.000), and also for min/hour of outdoor time in each time period, with p= 0.019 (before 10 am), 0.000 (between 10 am and 2 am) and 0.009 (after 2 pm), respectively.

Table 4.9 Comparison of outdoor time on weekdays and weekends

Outdoor time	**Mean** [1]	**95% CI**[1] **(LB-UB)**	**t value**	**Mean**[2]	**95% CI**[2] **(LB-UB)**
Before 10 am(minutes/hour)			**-2.355***		
weekdays†	1.07	0.93-1.20		2.90	2.54-3.32
weekends†	1.32	1.15-1.49		3.75	3.17-4.44
10 am – 2 pm(minutes/hour)			**-5.990****		
weekdays†	1.25	1.08-1.42		3.48	2.74-4.13
weekends†	1.99	1.81-2.16		7.31	6.14-8.71
After 2 pm(minutes/hour)			**-2.615****		
weekdays†	1.33	1.18-1.48		3.79	3.26-4.40
weekends†	1.64	1.46-1.81		5.13	4.31-6.11
Whole day(minutes/day)			**-5.071****		
weekdays‡	3.96	3.82-4.10		52.46	45.60-60.34
weekends‡	4.49	4.35-4.63		89.12	77.48-102.51

Note: 1 denotes ln(time), 2 denotes values anti-natural logarithmic transformed from 1. * denotes p value < 0.05, ** denotes p value < 0.01. CI denotes Confidence Interval, LU denotes Lower Bound, UB denotes Upper Bound. † denotes the unit is minutes/hour, while ‡ denotes the unit is minutes/day.

4.4.1.2 UV adjusted outdoor time

As has been described in Chapter 3 Research Design, a formula was used to calculate the UV adjusted outdoor time, in order to make outdoor time equivalent for vitamin D produced through sun exposure.

Total time (minutes) outdoor during the daytime (5 am to 7 pm) – UV adjusted:

UVadjusted outdoor time = $\sum_{i=1}^{14} O_i \times W_i$

- Where O_i: is during the time period *i*, the time (minutes) spent outdoors.
- $W_i$is the UV weight during the time period *i.*
- 14 meansa total of 14 hours from 5am to 7pm.

Using the formula above, the UV adjusted time spent outdoors on everyday was calculated, then adding the time of the seven days together to calculate the UV adjusted time spent outdoors of the whole week. After that, the whole time was divided by seven to calculate an average outdoor time for one day, called daily UV adjusted outdoor time. The daily UV adjusted outdoor time for all respondents ranged from zero minutes per day to 417 minutes per day, with 102.57 minutes per day (SD = 78.454) being the mean daily UV adjusted outdoor time, and the median daily UV adjusted outdoor time was 76.5 minutes per day. So, 95% CI: 90.45–114.66 minutes/day. P_{25} = 43.25 minutes/day, P_{75} = 146minutes/day. Skewness = 1.221 (SE= 0.19), kurtosis = 1.437(SE= 0.377).

As can be seen, daily UV adjusted outdoor time was a positively skewed distribution, so a natural logarithmic transformation was used, based on the constant e (2.72) before doing further analysis, after which these data were considered as normally distributed data.

4.4.1.3 Factors influencing daily UV adjusted outdoor time

Different demographic and obstetrical characteristics were explored, which may impact on the participants' daily UV adjusted outdoor time. All of the independent variables were categorised into either two or three groups, and the dependent variable was ln(UVadjusted time).

Bivariate analysis was conducted to identify important influencing factors (see Table 4.10).

Table 4.10 Factors and daily UV adjusted outdoor time

Factors	N (%)	Mean[1] (95%CI:LB-UB)	Test value	Mean[2] (95%CI:LB-UB)
Age group (years)			F = 0.197	
< 30	58 (35.4%)	4.34(4.09-4.59)		76.72(59.97-98.15)
30-34	68 (41.4%)	4.29(4.03-4.54)		72.74(56.48-93.69)
≥35	38 (23.2%)	4.21(3.95-4.48)		67.68(51.70-88.59)
Country of birth			t =-0.654	
Australia	134 (81.7%)	4.27(4.10-4.43)		71.24(60.39-84.02)
Non-Australia	30 (18.3%)	4.39(4.05-4.73)		80.82(57.54-87.51)
Resident region			t =-0.881	
Northern Australia	98 (59.8%)	4.24(4.06-4.41)		69.07(57.71-82.67)
Southern Australia	66 (40.2%)	4.37(4.11-4.62)		78.97(61.22-101.89)
Current employment			F = 2.4	
Full-time	85 (51.8%)	4.19(4.02-4.36)		66.25(55.87-78.56)
Part-time	38 (23.2%)	4.58(4.32-4.85)		97.85(75.10-127.49)
Others	41 (25.0%)	4.21(3.80-4.63)		67.65(44.86-102.01)
Educational level			F = 4.885**	
Under university	50 (30.5%)	4.24(3.94-4.54)[a,b]		69.33(51.25-93.78)
Bachelor	72 (43.9%)	4.52(4.35-4.69)[a]		91.59(77.39-108.38)
Postgraduate	42 (25.6%)	3.96(3.62-4.30)[b]		52.32(37.33-73.35)
Season			t =-1.074	
Winter	107 (65.2%)	4.23(4.04-4.42)		68.77(56.73-83.35)
Spring/Summer	57 (34.8%)	4.40(4.14-4.44)		81.34(64.88-101.97)
Skin colour			t =-0.785	
Fair	104 (63.4%)	4.24(4.06-4.43)		69.72(57.99-83.84)
Medium/Olive	60 (36.6%)	4.37(4.12-4.62)		78.74(61.31-101.15)
Skin burn capacity			F = 1.352	
Burn within ½ hour	56 (34.1%)	4.23(3.99-4.48)		69.03(53.82-88.54)
Burn in ½ - 1 hour	48 (29.3%)	4.16(3.89-4.43)		63.92(48.90-83.58)
Burn after 1 hour	60 (36.3%)	4.45(4.19-4.70)		85.20(65.88-110.18)
Pre-pregnancy BMI			t = 0.655	
< 25	101 (61.6%)	4.33(4.18-4.48)		76.08(65.52-88.34)
≥ 25	63 (38.4%)	4.22(3.92-4.53)		68.07(50.19-92.31)

Factors	N (%)	Mean[1] (95%CI:LB-UB)	Test value	Mean[2] (95%CI:LB-UB)
Trimester			t =-1.254	
Second	127 (77.4%)	4.24(4.07-4.41)		69.32(58.48-82.16)
Third	37 (22.6%)	4.46(4.16-4.76)		86.65(64.25-116.85)
Gravidity			F = 0.436	
1	71 (43.2%)	4.22(4.03-4.41)		67.81(56.07-82.01)
2	48 (29.3%)	4.31(4.00-4.61)		74.16(54.86-100.24)
≥3	45 (27.4%)	4.38(4.06-4.71)		80.23(57.90-111.16)
Parity			t = -2.955**	
0	87 (53.0%)	4.09(3.88-4.29)		59.54(48.59-72.94)
≥1	77 (47.0%)	4.52(4.31-4.72)		91.62(74.55-112.62)
Miscarriage history			t = 0.847	
0	122 (74.4%)	4.33(4.14-4.44)		75.65(64.65-88.52)
≥1	42 (25.6%)	4.18(3.82-4.54)		65.46(45.65-93.85)

Note: 1 denotes ln(UV-adjusted time), 2 denotes values anti-natural logarithmic transformed from 1. * denotes p value < 0.05, ** denotes p value < 0.01. a,b,c denotes statistical significance from each other group underlying one category. CI denotes Confidence Interval, LB denotes Lower Bound, UB denotes Upper Bound.

(a) Age group and daily UV adjusted outdoor time

In this analysis, age was categorised into three groups: < 30 years old, 30-34 years old and ≥ 35 years old. The mean daily UV adjusted outdoor times were 76.72 minutes per day for the< 30 years old group, 72.74 minutes per day for the 30-34 year old group and 67.68 minutes per day for the ≥ 35 years old group. A one-way between-groups ANOVA was conducted to explore the impact of age on the daily UV adjusted outdoor time. There was no statistically significant difference (p=0.822) in the daily UV adjusted outdoor time among the three age groups.

(b) Country of birth and daily UV adjusted outdoor time

In this analysis, because the majority of participants were born in Australia (81.7%), "country of birth" was categorised into two groups: Australian born and non-Australian born. The mean daily UV adjusted outdoor times were 71.24 minutes per day for the Australian born group and 80.82 minutes per day for the non-Australian born group. An independent samples t test was conducted to compare the daily UV adjusted outdoor time for the Australian born and non-Australia born groups. The difference was not statistically significant (p=0.514) in the daily UV adjusted outdoor time between these two groups.

(c) Resident region and daily UV adjusted outdoor time

In this analysis, resident region was categorised into two groups: Northern Australia and Southern Australia. The mean daily UV adjusted outdoor times were 69.07 minutes per day for the Northern Australia group and 78.79 minutes per day for the Southern Australia group. An independent samples t test was conducted to compare the daily UV adjusted outdoor time for the Northern Australia and Southern Australia groups. No statistically significant difference (p=0.379) was detected in the daily UV adjusted outdoor time between these two groups.

(d) Current employment status and daily UV adjusted outdoor time

In this analysis, current employment status was categorised into three groups: full-time working, part-time working, and others, which included unemployed, home duties, student, maternity leave and sole parent pension. The mean daily UV adjusted outdoor times were 66.25 minutes per day for the full-time working group, 97.85 minutes per day for the part-time working group and 67.68 minutes per day for the others group. A one-way between-groups ANOVA was conducted to explore the impact of current employment status on the daily UV adjusted outdoor time. There was no statistically significant difference (p=0.094) in the daily UV adjusted outdoor time for the three current employment status groups.

(e) Educational level and daily UV adjusted outdoor time

In this analysis, because participants in this study were mainly at a high educational level, the educational level was categorised into three groups: under university group, including “Some High School (Year 11 or under)”, “Year 12 Senior Certificate (or HSC)” and “Certificate or Diploma”; bachelor’s degree group; and postgraduate degree group. The mean daily UV adjusted outdoor times were 69.33 minutes per day for the under university group, 91.59 minutes per day for the bachelor’s degree group and 52.32 minutes per day for the postgraduate degree group. A one-way between-groups ANOVA was conducted to explore the impact of educational level on the daily UV adjusted outdoor time. There was a total, statistically significant difference (p=0.009) in the daily UV adjusted outdoor time for the three education groups. Posthoc comparisons, using an LSD test, indicated that the mean UVadjusted outdoor time for the bachelor's degree group was significantly increased from the postgraduate degree group (p=0.002), but no significant difference was found either between the under university group and the bachelor's degree group (p=0.107), nor between the under university group and the postgraduate degree group (p=0.151). Compared to women with a postgraduate degree, women with a bachelor's degree had a longer daily UV adjusted outdoor time.

(f) Season and daily UV adjusted outdoor time

In this analysis, because most participants were recruited in the winter season (65.2%), the seasons were categorised into two groups: the winter season and the spring + summer seasons. The mean daily UV adjusted outdoor times were 68.77 minutes per day for the winter group and 81.34 minutes per day for thespring+summer group. An independent samples t test was conducted to compare the daily UV adjusted outdoor time for the winter season and the spring+summer seasons. There was no statistically significant difference (p= 0.284) in the daily UV adjusted outdoor time between these two groups.

(g) Skin colour and daily UV adjusted outdoor time

In this analysis, because most participants (63.4%) self-reported their natural skin colour as fair, and no one was "black", skin colour was categorised into two groups: fair skin colour and medium + olive skin colours. The mean daily UV adjusted outdoor times were 69.72 minutes per day for the fair skinned group and 78.74 minutes per day for themedium+olive skinned group. An independent samples t test was conducted to compare the daily UV adjusted outdoor time for the fair skin colour group and the medium+olive skin colour group. No statistically significant difference (p=0.434) was detected in the daily UV adjusted outdoor time between these two groups.

(h) Skin burn capacity and daily UV adjusted outdoor time

In this analysis skin burn capacity was categorised into three groups: "burn within ½ hour", "burn in ½ - 1 hour" and "burn after 1 hour". The mean daily UV adjusted outdoor times were 69.03 minutes per day for the "burn within ½ hour" group, 63.92 minutes per day for the "burn in ½ - 1 hour" group and 85.20 minutes per day for the "burn after 1 hour" group. There was no statistically significant difference (p=0.262) in the daily UV adjusted outdoor time for the three skin burn capacity groups.

(i) Pre-pregnancy BMI and daily UV adjusted outdoor time

In this analysis, BMI was categorised into two groups: < 25 for underweight and normal weight and ≥ 25 for overweight and obese. The mean daily UV adjusted outdoor times were 76.08 minutes per day for the< 25 group and 68.07 minutes per day for the ≥ 25 group. An independent samples t test was conducted to compare the daily UV adjusted outdoor time for the underweight/normal weight group and overweight/obese group. There was no statistically significant difference (p=0.514) in the daily UV adjusted outdoor time between these two groups.

(j) Trimester and daily UV adjusted outdoor time

In this analysis, trimester was categorised into two groups: second trimester and third trimester. The mean daily UV adjusted outdoor times were 59.32 minutes per day for the second trimester group and 86.63 minutes per day for the third trimester group. An independent samples t test was conducted to compare the daily UV adjusted outdoor time for the second trimester and the third trimester groups. There was no statistically significant difference (p=0.212) in the daily UV adjusted outdoor time between these two groups.

(k) Gravidity and daily UV adjusted outdoor time

In this analysis, gravidity was categorised into three groups: first pregnancy, second pregnancy, and third or over pregnancy. The mean daily UV adjusted outdoor times were 67.81 minutes per day for the first pregnancy group, 74.16 minutes per day for the second pregnancy group and 80.23 minutes per day for the third or over pregnancy group. A one-way between-groups ANOVA was conducted to explore the impact of gravidity on the daily UV adjusted outdoor time. There was no statistically significant difference (p=0.648) in the daily UV adjusted outdoor time for the three gravidity groups.

(l) Parity and daily UV adjusted outdoor time

In this analysis, parity was categorised into two groups: never laboured and laboured at least once. An independent samples t test was conducted to compare the daily UV adjusted outdoor times for the zero parity (never laboured before) group and the ≥1 parity (laboured at least once before) group. The mean daily UV adjusted outdoor times were 59.54 minutes per day for the zero parity group and 91.62 minutes per day for the ≥1 parity group. There was a statistically significant difference (p=0.04) in the daily UV adjusted outdoor time between these two groups, indicating that women who had not laboured before spent less UV adjusted outdoor time every day than those women who had laboured at least once before.

(m) Miscarriage history and daily UV adjusted outdoor time

In this analysis, miscarriage history was categorised into two groups: never had a miscarriage, set at "0", and had at least one miscarriage, set at "≥ 1". The mean daily UV adjusted outdoor times were 75.65 minutes per day for the no miscarriage history group and 65.46 minutes per day for the have had at least one miscarriage history group. An independent samples t test was conducted to compare the daily UV adjusted outdoor times for the never had miscarriage history group and the have had at least one miscarriage history group. There was no statistically significant difference (p=0.398) in the daily UV adjusted outdoor time between these two groups.

Overall, by using a bivariate analysis, educational levels and parity showed a significant impact on the daily UV adjusted outdoor time among pregnant women in Australia. Women with a bachelor's degree had more daily UV adjusted outdoor time than women with a postgraduate degree, and women labouring before spent more daily UV adjusted outdoor time than women without labour before.

A multiple regression analysis (general linear model) was conducted to assess whether there were any significant changes from the bivariate analyses after controlling for covariates. The four variables were educational level, current employment status, season and parity ($p < 0.2$ from bivariate analysis), plus two variables chosen from literature, skin burn capacity and trimester, were regarded as more important factors of UV adjusted outdoor time and were entered in this model simultaneously. The results are shown in Table 4.11.

Table 4.11 General linear model for UV adjusted outdoor time

Independent Variable	B	95% CI LB-UB	F/t value	P-value
Current employment			1.753	0.177
Full-time	0.191	-0.195, 0.577	0.978	0.329
Part-time	0.395	-0.022, 0.812	1.871	0.063
Others	Reference			
Educational level			4.348	0.015*
Under university	0.263	-0.125, 0.651	1.338	0.183
Bachelor	0.517	0.167, 0.867	2.927	0.004**
Postgraduate	Reference			
Season				
Winter	-0.217	-0.516, 0.083	-1.429	0.155
Spring+Summer	Reference			
Skin burn capacity				0.207
Burn after 1 hour	0.230	-0.107, 0.567	1.351	0.179
Burn in ½ - 1 hour	-0.028	-0.383, 0.327	-0.155	0.877
Burn within ½ hour	Reference			
Trimester				
Second	-0.198	-0.551, 0.155	-1.110	0.269
Third	Reference			
Parity				
≥1	0.419	0.107, 0.731	2.654	0.009**
0	Reference			

Note: The analysis was based on ln(UVadjusted time). CI denotes Confidence Interval, LB denotes Lower Bound, UB denotes Upper Bound. * denotes p value < 0.05, ** denotes p value < 0.01.

As can be seen from Table 4.11, after adjustment for current employment, season, skin burn capacity and trimester, educational level and parity still showed statistical significance on the daily UV adjusted outdoor time. Compared to postgraduate women, pregnant women with a bachelor's degree spent more daily UV adjusted outdoor time (B=0.517, 95% CI: 0.167 - 0.867, p=0.002). Multiparous women were found to have increased daily UV adjusted outdoor time over nulliparous women (B=0.419, 95% CI: 0.107 - 0.731, p=0.009).

4.4.2 Clothing

4.4.2.1 Clothing patterns

Over half (68.3%) of the women did not wear a broad-brimmed hat whilst outside in the past month, while 7.9% and 6.7% chose to wear one "always or almost always" and "more than the half time", respectively. For cap wearing, 65.9% did not wear a cap, only 6.1% and 7.9% wore a cap "always or almost always" and "more than the half time", respectively. Also, almost all women (92.1%) did not wear any other head covering. When asked if they wore a shirt with long sleeves when outdoors in the past month, 31.1% chose "always or almost always", 27.4% wore one"more than half the time" and 21.3% reported "less than half the time". There were still 20.1% who wore a long-sleeved shirt "never or rarely". When choosing to cover legs with clothing, 39.6% and 36.6% women chose to cover up "all or most" of their legs "always or almost always" and "more than half the time", respectively, while 9.8% wore leg covering "less than half the time"and 14% wore it"never or rarely". With regard to wearing sunglasses, most women wore sunglasses in the past month when staying outside, including 48.8% "always or almost always" and 18.9% "more than half the time", respectively, however, 18.9% and 13.4% still chose to wear sunglasses "less than half the time" or "never or rarely".

Table 4.12 Clothing patterns

	Never/Rarely	**Less than half the time**	**More than half the time**	**Always/Almost always**
Wear a broad-brimmed hat	112(68.3%)	28(17.1%)	11(6.7%)	13(7.9%)
Wear a cap	108(65.9%)	33(20.1%)	13(7.9%)	10(6.1%)
Wear any other head covering	151(92.1%)	10(6.1%)	2(1.2%)	1(0.6%)
Wear a shirt with long sleeves	33(20.1%)	35(21.3%)	45(27.4%)	51(31.1%)
Wear long trousers or clothing that covers all or most of your legs	23(14.0%)	16(9.8%)	60(36.6%)	65(39.6%)
Wear sunglasses	22(13.4%)	31(18.9%)	31(18.9%)	80(48.8%)

4.4.2.2 *Total clothing score*

As has been described in Chapter 3 Research Design, every participant was given a total clothing score to represent the percentage of a person's whole surface area that is covered by clothing.

Total clothing score = (head cover frequency score × 0.4 + long-sleeve shirt frequency score × 1.4 + long pants frequency score × 1.8)/3+5.7

Using the formula above, a total clothing score was calculated for every participant. The total clothing score of the whole respondents ranged from 5.7 to 9.3, with 7.83 (SD = 1.06) of the mean total clothing score, and the median clothing score was 7.87. So, 95% CI: 7.67-7.99. P_{25} = 7.03, P_{75} = 8.90. Skewness = -0.49 (SE= 0.190), kurtosis = -0.68 (SE=0.377). The data were roughly normally distributed.

4.4.2.3 *Factors influencing total clothing score*

Different demographic and obstetrical characteristics that may impact on the participants' total clothing score were explored. All of the independent variables were categorised into either two or three groups, as in the previous section, and the dependent variable was the total clothing score (see Table 4.13).

Table 4.13 Factors and total clothing score

Factors	N (%)	Mean	95% CI (LB -UB)	Test value
Age group (years)				F = 0.835
< 30	58 (35.4%)	7.69	7.39 - 7.98	
30-34	68 (41.4%)	7.91	7.67 - 8.45	
≥35	38 (23.2%)	7.91	7.56- 8.25	
Country of birth				t = 0.833
Australia	134 (81.7%)	7.86	7.68 - 8.04	
Non-Australia	30 (18.3%)	7.68	7.26 - 8.11	
Resident region				t = -4.157**
Northern Australia	98 (59.8%)	7.56	7.35 - 7.77	
Southern Australia	66 (40.2%)	8.23	8.00 - 8.46	
Current employment				F = 0.053
Full-time	85 (51.8%)	7.82	7.60 - 8.03	
Part-time	38 (23.2%)	7.81	7.45 - 8.18	
Others	41 (25.0%)	7.88	7.52 - 8.24	

Factors	N (%)	Mean	95% CI (LB -UB)	Test value
Educational level				F = 1.213
Under university	50 (30.5%)	7.85	7.55 - 8.15	
Bachelor	72 (43.9%)	7.70	7.45 - 7.96	
Postgraduate	42 (25.6%)	8.02	7.70 - 8.34	
Season				t = 1.777
Winter	107 (65.2%)	7.94	7.83 - 8.14	
Spring+Summer	57 (34.8%)	7.63	7.36 - 7.90	
Skin colour				t = 1.850
Fair	104 (63.4%)	7.95	7.77 - 8.14	
Medium+Olive	60 (36.6%)	7.62	7.31 - 7.93	
Skin burn capacity				F = 2.245
Burn within ½ hour	56 (34.1%)	8.06	7.82 - 8.31	
Burn in ½ - 1 hour	48 (29.3%)	7.64	7.32 - 7.97	
Burn after 1 hour	60 (36.3%)	7.76	7.48 - 8.05	
Pre-pregnancy BMI				t = 0.773
< 25	101 (61.6%)	7.88	7.67 - 8.09	
≥ 25	63 (38.4%)	7.75	7.48 - 8.02	
Trimester				t = 1.063
Second	127 (77.4%)	7.88	7.69 - 8.07	
Third	37 (22.6%)	7.67	7.33 - 8.00	
Gravidity				F = 1.610
1	71 (43.2%)	7.67	7.41 - 7.92	
2	48 (29.3%)	8.00	7.71 - 8.30	
≥3	45 (27.4%)	7.90	7.58 - 8.22	
Parity				t = -1.447
0	87 (53.0%)	7.72	7.49 - 7.95	
≥1	77 (47.0%)	7.96	7.73 - 8.19	
Miscarriage history				t = -0.507
0	122 (74.4%)	7.81	7.61 - 7.99	
≥1	42 (25.6%)	7.90	7.57 - 8.24	

Note: ** denotes p value < 0.01. CI denotes Confidence Interval, LB denotes Lower Bound, UB denotes Upper Bound.

Using the same statistical method and procedure as in the UV adjusted outdoor time section, only the resident region was detected as having a statistically significant difference between groups at the 0.05 level. Women living in Southern Australia (mean = 8.23, 95% CI: 8.00-8.46) wore more clothing than women living in

Northern Australia (mean = 7.56, 95% CI: 7.35-7.77, $p = 0.000$).Season and skin colour tended to be significant with a p value = 0.077 and 0.067, respectively. In winter, women tended to have a higher clothing score than in spring+summer (mean = 7.94, 95% CI: 7.83–8.14 versus mean = 7.63, 95% CI: 7.36 – 7.90). The mean of total clothing score was higher for participants with fair skin colour (mean=7.95, 95% CI: 7.77-8.14) than for those participants whose skin colour was medium or olive (mean=7.62, 95% CI: 7.31-7.93).

A multiple regression analysis (general linear model) was conducted to assess whether there were any significant changes from the bivariate analyses after controlling for covariates. Six variables, resident region, season, skin colour, skin burn capacity, parity and gravidity, were regarded as more important factors ($p < 0.2$ from bivariate analysis) of the total clothing score and were entered in this model simultaneously. The results are shown in Table 4.14.

Table 4.14 General linear model for total clothing score

Independent variable	B	95% CI LB-UB	F/tvalue	P-value
Resident region				
Northern Australia	-0.663	-0.981, -0.344	-4.110	0.000**
Southern Australia	Reference			
Season				
Winter	0.412	0.081, 0.743	2.461	0.015*
Spring+Summer	Reference			
Skin colour				
Fair	0.300	-0.085, 0.685	1.539	0.126
Medium+Olive	Reference			
Skin burn capacity			1.595	0.206
Burn after 1 hour	-0.102	-0.545, 0.341	-0.454	0.650
Burn in ½ - 1 hour	-0.342	-0.733, 0.049	-1.727	0.086
Burn in ½ hour	Reference			
Gravidity				0.863
≥3	0.112	-0.424, 0.647	0.411	0.681
2	0.147	-0.388, 0.681	0.542	0.588
1	Reference			
Parity				
≥1	0.028	-0.461, 0.517	0.113	0.910
0	Reference			

Note: CI denotes Confidence Interval, LB denotes Lower Bound, UB denotes Upper Bound. * denotes p value < 0.05, ** denotes p value < 0.01.

As can be seen from Table 4.14, after adjustment, residential region was still significant in the total clothing score and pregnant women in Northern Australia covered themselves less than those in Southern Australia (B=-0.663, 95% CI: -0.981～-0.344, p=0.000). However, after adjustment, there was also a significant difference between winter and spring+summer. In winter, pregnant women wore more than women in spring+summer (B=0.412, 95% CI: 0.081～0.743, p =0.015).

4.4.3 Sunscreen Use

4.4.3.1 Description of sunscreen use

In terms of sunscreen use in the participants' past month, nearly half (48.8%) reported that they had applied it in that time. Within them, only three respondents rated their sunscreen SPF as less than 30.The majority of them (65%) had applied sunscreen almost every day (5-7 days a week/every day), and most of them (88.8%) had applied it once or twice a day. Participants were more likely to apply sunscreen on their body surfaces that were more frequently exposed to sunlight, such as the face (98.8%), neck (90%) and forearms (75%). Surfaces such as the trunk and thighs, which were more likely to be covered by clothing, had sunscreen applied less often; only 7.5% and 8.8% respectively.

Table 4.15 Description of sunscreen use for whole sample (N = 164)

Sunscreen use	N (%)
Yes	***80(48.8%)[1]***
SPF 30+	77(96.3%)[2]
5-7 days/week or every day	52(65%)[2]
Once or twice a day	71(88.8%)[2]
Face	79(98.8%)[2]
Neck	72(90%)[2]
Trunk	6(7.5%)[2]
Upper arms	41(51.3%)[2]
Forearms	60(75%)[2]
Hands	55(68.8%)[2]
Thighs	7(8.8%)[2]
Lower legs	21(26.3%)[2]
Feet	18(22.5%)[2]
No	***84(51.2%)[1]***

Note: 1 denotes percentage based on total sample size 164, 2 denotes percentage based on “Yes” sample size 80.

4.4.3.2 Factors influencing sunscreen use

Different demographic and obstetrical characteristics that may impact on participants’ sunscreen use were explored. All of the independent variables were categorised into either two or three groups as in the previous section, but the dependent variable was sunscreen use. Sunscreen use was categorized into two groups: “Yes” group or “No” group (see Table 4.16).

Table 4.16 Factors and sunscreen use

Factors	N (%[1])	Sunscreen use "Yes" N (%[2])	95% CI[2] (LB - UB)	χ^2 value
Age group (years)				
< 30	58 (35.4%)	29(50.0%)	37.5-62.5%	0.324
30-34	68 (41.4%)	34(50.0%)	38.4-61.6%	
≥35	38 (23.2%)	17(44.7%)	30.1-60.3%	
Country of birth				
Australia	134 (81.7%)	68(50.7%)	42.4-59.1%	1.033
Non-Australia	30 (18.3%)	12(40.0%)	24.6-57.7%	
Resident region				
Northern	98 (59.8%)	57(58.2%)	48.3-67.4%	8.580**
Southern	66 (40.2%)	23(34.8%)	24.5-46.9%	
Current employment				
Full-time	85 (51.8%)	45(52.9%)	42.4-63.2%	
Part-time	38 (23.2%)	21(55.3%)	39.7-69.9%	4.742
Others	41 (25.0%)	14(34.1%)	21.6-49.5%	
Educational level				
Under university	50 (30.5%)	23(46%)	33.0-59.6%	0.826
Bachelor	72 (43.9%)	38(52.8%)	41.4-63.9%	
Postgraduate	42 (25.6%)	19(45.2%)	31.2-60.1%	
Season				
Winter	107 (65.2%)	38(35.5%)	27.1-44.9%	21.686**
Spring+Summer	57 (34.8%)	42(73.7%)	61.0-83.4%	
Skin colour				
Fair	104 (63.4%)	56(53.8%)	44.3-63.1%	2.920
Medium+Olive	60 (36.6%)	24(40.0%)	28.6-52.6%	
Skin burn capacity				
Burn within ½ hour	56 (34.1%)	35(62.5%)[a]	49.4-74.0%	7.757*
Burn in ½ - 1 hour	48 (29.3%)	23(47.9%)[a,b]	34.5-61.7%	
Burn after 1 hour	60 (36.3%)	22(36.7%)[b]	25.6-49.3%	
Pre-pregnancy BMI				
< 25	101 (61.6%)	46(45.5%)	36.2-55.2%	1.102
≥ 25	63 (38.4%)	34(54.0%)	41.8-65.7%	
Trimester				
Second	127 (77.4%)	67(52.8%)	44.1-61.2%	3.561
Third	37 (22.6%)	13(35.1%)	21.8-51.2%	

Factors	N (%[1])	Sunscreen use "Yes" N (%[2])	95% CI[2] (LB - UB)	χ^2 value
Gravidity				
1	71 (43.2%)	40(56.3%)	44.8-61.2%	
2	48 (29.3%)	23(47.9%)	34.5-61.7%	3.818
≥3	45 (27.4%)	17(37.8%)	25.1-52.4%	
Parity				
0	87 (53.0%)	46(52.9%)	42.5-63.0%	1.242
≥1	77 (47.0%)	34(44.2%)	33.6-55.3%	
Miscarriage history				
0	122 (74.4%)	62(50.8%)	42.1-59.5%	0.793
≥1	42 (25.6%)	18(42.9%)	29.1-57.8%	

Note: 1 denotes percentage based on total sample size 164, 2 denotes percentage based on each group sample size. * denotes p value < 0.05, ** denotes p value < 0.01. a,b denote statistical significance from each other group underlying one category. CI denotes Confidence Interval, LB denotes Lower Bound, UB denotes Upper Bound.

(a) Age group and sunscreen use

A total of 58 participants were in group 1 (age < 30years old) and in 64 in Group 2 (aged between 30 and 34).Half of the pregnant women applied sunscreen in the past month in both groups, the 95%CI of using sunscreen were: 37.5-62.5% in Group 1 and 38.4-61.6% in Group 2. In Group 3 (age ≥ 35 years old), 17 pregnant women applied sunscreen in the last month from a total of 38 participants (95% CI: 30.1-60.3%). A chi-square test was conducted to compare the sunscreen use ratio in the three age groups, but no statistically significant difference (p=0.851) was found.

(b) Country of birth and sunscreen use

From a total of 134 Australian born participants, 68 pregnant women had applied sunscreen in the past month, with 95% CI: 42.4-59.1%, while 12 had applied it from 30 non-Australian born women, with 95% CI: 24.6-57.7%. A chi-square test was conducted to compare the sunscreen use ratio in the two different birth country groups, but no statistically significant difference (p=0.287) was found.

(c) Resident region and sunscreen use

Living in Northern Australia were 98 participants, among whom 57 pregnant women reported that they had applied sunscreen in the past month (95% CI: 48.3-67.4%), while only 23 women had applied sunscreen in the past month among the 66 women living in Southern Australia (95% CI: 24.5-46.9%). A chi-square test was conducted to compare the sunscreen use ratio in the two different living areas. There was a statistically significant difference (p=0.003) in the sunscreen use ratio among pregnant women living in the two areas. More pregnant women living in Northern Australia had applied sunscreen than those women living in Southern Australia.

(d) Current employment status and sunscreen use

Of the 85 participants who were still in full-time work, 45 pregnant women had applied sunscreen in the previous month (95% CI: 42.4-63.2%), while 21 women among 38 part-time working pregnant women had applied sunscreen in the previous month (95% CI: 39.7-69.9%). Of the 41 women who were unemployed, doing home duties or taking maternity leave, 14 women said they had applied sunscreen in the previous month, so the usage percentages of 95% CI were 21.6-49.5% in this group. A chi-square test was conducted to compare the sunscreen use ratio in the three different employment status groups, and no statistically significant difference (p=0.093) was found.

(e) Educational level and sunscreen use

The sunscreen use ratios in three education levels were roughly equal. Of the 50 participants who had obtained the "under university" level, that is, some high school, year 12 senior, certificate or diploma, 23 had used sunscreen (95% CI: 33.0-59.6%).There were 38 sunscreen users from 72 women with a bachelor's degree (95% CI:41.4-63.9%) and 19 out of 42 with a postgraduate degree (95% CI: 31.2-60.1%). There was no statistically significant difference (p=0.662) between these three groups after conducting a chi-square test.

(f) Season and sunscreen use

During the winter season, only 38 pregnant women out of a total of 107 participants had applied sunscreen in the previous month (95% CI 27.1-44.9%), while 42 women from a total of 57 participants applied sunscreen in the spring+summer season (95% CI: 61.0-83.4%). A chi-square test was conducted to compare the sunscreen use ratio in seasons found a statistically significant difference (p=0.000) in sunscreen use between the winter season and the spring+summer season. In winter, fewer pregnant women applied sunscreen than in spring+summer.

(g) Skin colour and sunscreen use

In terms of the impact of skin colour on sunscreen use, 56 pregnant women had applied sunscreen in the previous month from 104 participants with fair skin (95% CI: 44.3-63.1%). Also, 24 out of 60 participants who had reported their skin colour as either medium or olive had applied sunscreen (95% CI: 28.6-52.6%). Even though no statistical significance between these two skin colour groups was found, the p value (0.088) was fairly close to a significant level, at 0.05.

(h) Skin burn capacity and sunscreen use

Pregnant women were more specifically categorized into three skin conditions according to participants' skin capacity of getting burnt. Of the 56 participants whose skin was burnt "within ½ hour" when sitting in the sun without sunscreen in the middle of the day for the first time in summer, 35 women had applied sunscreen in the previous month (95%CI: 49.4-74.0%), 23 women, inform a total of 48 women whose skin got burnt "after ½ - 1 hour", had applied sunscreen (95% CI: 34.5-61.7%), while 22 had applied sunscreen out of 60 women with skin that burnt "after 1 hour" (25.6-49.3%). When performing a chi-square test, a statistical significance (p=0.021) was found between the three groups. The Boniferroni method z-test for comparing proportions indicated that significantly more pregnant women applied sunscreen whose skin burnt "within ½ hour" than those who burnt "after 1 hour", but no statistical significance was found either between women with skin that burnt "within ½ hour" and "in ½-1 hour", or between "in ½-1 hour" and "after 1 hour".

(i) Pre-pregnancy BMI and sunscreen use

Due to the small sample size, pregnant women were categorized into two groups according to their pre-pregnancy BMI. Of women with a pre-pregnancy BMI of less than 25, 46 out of 101 had applied sunscreen with 95% CI: 36.2~55.2%, while 34 from a total of 63 women whose pre-pregnant BMI was ≥25 had applied it, with 95% CI: 41.8~65.7%. No significant difference (p=0.294) was found between these two groups.

(j) Trimester and sunscreen use

Second trimester pregnant women totalled 127, of whom 67 women had used sunscreen (95% CI: 44.1-61.2%), while among 37 pregnant women in their third trimester, there were 13 women who had applied sunscreen (95% CI: 21.8-51.2%). There was no significance between these two groups, but the p vale was 0.059, very close to the significant level of 0.05. The proportion of using sunscreen is higher among women in second trimester than in third trimester, but this relationship did not research statistical significance (p=0.059).

(k) Gravidity and sunscreen use

Among 71 women with a first time pregnancy, 40 pregnant women had applied sunscreen (95% CI: 44.8-61.2%). Of women with a second time pregnancy, 23 out of 48 had applied sunscreen (95% CI: 34.5-61.7%) and 17 women had applied sunscreen in the previous month out of 45 women in their third or over pregnancy (95% CI:25.1-52.4%). A chi-square test conducted to compare the sunscreen use ratio in gravidity found no statistically significant difference (p=0.148) between the first time, second time and third or over pregnancies in sunscreen use.

(l) Parity and sunscreen use

Among 87 women who had never given birth before, 46 women had applied sunscreen in the previous month (95% CI: 42.5-63.0%). There were 34 from a total of 77 participants who had at least given birth once before and who had applied sunscreen previous month (95% CI: 33.6-55.3%). No significance (p=0.265) was found in sunscreen use between these two groups.

(m) Miscarriage history and sunscreen use

Of 122participants in Group 1, who had no miscarriage history, 62 had used sunscreen (95% CI: 42.1-59.5%) and there were 18 sunscreen users from the 42 (95% CI: 29.1-57.8%)in Group 2, who had had at least one miscarriage. A chi-square test was conducted to compare the sunscreen use between the two groups, but no statistically significant difference (p=0.373) was found.

Overall, by using a bivariate analysis, resident region, the season and skin burn capacity showed a significant impact on sunscreen use. Even though the trimester, current employment status and skin colour did not show statistical significance, their p values were close to a significant level (0.05).

A binary logistic regression was conducted to assess whether there were any significant changes from the bivariate analyses after controlling for covariates. Six variables ($p < 0.2$), as mentioned above, resident region, current employment status, season, skin colour, skin burn capacity and trimester, were regarded as more important factors in sunscreen use, and were entered in this model simultaneously. The results are shown in Table 4.17.

Table 4.17 Binary logistic regression for sunscreen use (N=164)

Independent variable	**B**	**Wald χ^2**	**OR**	**95%CI LB-UB**	**Pvalue**
Resident region	1.649	14.357	5.201	2.216, 12.204	0.000**
Current employment					
Full-time	0.608	1.578	1.837	0.711, 4.744	0.209
Part-time	1.154	3.722	3.171	0.982, 10.239	0.054
Others	Reference	3.731			0.155
Season	-2.141	21.994	0.118	0.048, 0.288	0.000**
Skin colour	0.315	0.461	1.370	0.552, 3.395	0.497
Skin burn capacity					
Burn after 1 hour	-1.033	3.800	0.356	0.126, 1.006	0.051
Burn in ½ - 1 hour	-0.668	2.013	0.513	0.204, 1.290	0.156
Burn in ½ hour	Reference	4.046			0.132
Trimester	0.519	1.271	1.681	0.682, 4.416	0.259

Note:CI denotes Confidence Interval, LB denotes Lower Bound, UB denotes Upper Bound. * denotes p value < 0.05, ** denotes p value < 0.01.

As can be seen from Table 4.17, after adjustment, the resident region and season were still significant in sunscreen usage. Pregnant women in Northern Australia were more likely to apply sunscreen than those in Southern Australia (OR= 5.201, 95% CI: 2.216 – 12.204, p=0.000). In winter, pregnant women were less likely to use sunscreen than in spring+summer (OR=0.118, 95% CI: 0.048 – 0.288). However, skin burn capacity, which was detected as being statistically significant in the bivariate analysis, was no longer significant after being adjusted by other covariates in this model.

4.5 VITAMIN D INTAKE

4.5.1 Dietary Vitamin D Intake

4.5.1.1 Description of dietary vitamin D intake

As has been described in the section for data analysis in Chapter 3 Research Design, daily dietary vitamin D intake was calculated according to each participant's consumption of food that potentially contained vitamin D in the previous month.

In this population, the daily dietary vitamin D intake amount in the previous month varied from 0 µg per day to 18 µg per day , with a mean value of 1.89 µg per day (SD=2.10, 95% CI: 1.57-2.22) and a median value of 1.38 µg per day. The skewness was 3.927 (SE=0.190) and kurtosis was 24.375 (SE=0.377), indicating that the distribution of these data were skewed.

4.5.1.2 Factors influencing dietary vitamin D intake

Using the median value, we categorised pregnant women into two groups: women in the < 1.38 µg per day group, and women in the ≥ 1.38 µg per day group. Then, we explored different demographic and obstetrical characteristics that may impact on their choice. All of the independent variables were categorised into either two or thrree groups, as in the previous section, and the dependent variable was daily dietary vitamin D intake < 1.38 µg per day or ≥ 1.38 µg per day (see Table 4.18).

Table 4.18 Factors and daily dietary vitamin D intake

Factors	N (%[1])	N (%[2])vitamin D "≥1.38µg/day"	95% CI[2] (LB-UB)	χ^2 value
Age group (years)				
< 30	58 (35.4%)	29(50.0%)	37.5-62.5%	0.000
30-34	68 (41.4%)	34(50.0%)	38.4-61.6%	
≥35	38 (23.2%)	19(50.0%)	34.8-65.2%	
Country of birth				
Australia	134 (81.7%)	67(50.0%)	41.7-58.3%	0.000
Non-Australia	30 (18.3%)	15(50.0%)	33.2-66.8%	
Residence region				
Northern	98 (59.8%)	46(46.9%)	37.4-56.7%	0.913
Southern	66 (40.2%)	36(54.5%)	42.6-66.0%	

Factors	N (%[1])	N (%[2])vitamin D "≥1.38μg/day"	95% CI[2] (LB-UB)	χ^2 value
Current employment				
Full-time	85 (51.8%)	39(45.9%)	35.7-56.4%	
Part-time	38 (23.2%)	25(65.8%)	49.9-78.8%	4.973
Others	41 (25.0%)	18(43.9%)	29.9-59.0%	
Educational level				
Under university	50 (30.5%)	27(54.0%)	40.4-67.0%	0.701
Bachelor	72 (43.9%)	36(50.0%)	38.7-61.3%	
Postgraduate	42 (25.6%)	19(45.2%)	31.2-60.1%	
Season				
Winter	107 (65.2%)	56(52.3%)	43.0-61.6%	0.672
Spring/Summer	57 (34.8%)	26(45.6%)	33.4-58.4%	
Skin colour				
Fair	104 (63.4%)	52(50.0%)	40.6-59.4%	0.000
Medium/Olive	60 (36.6%)	30(50.0%)	37.7-62.3%	
Skin burn capacity				
Burn within ½ hour	56 (34.1%)	26(26.4%)	34.0-59.3%	1.102
Burn in ½ - 1 hour	48 (29.3%)	27(56.3%)	42.3-69.3%	
Burn after 1 hour	60 (36.3%)	29(48.3%)	36.2-60.7%	
Pre-pregnancy BMI				
< 25	101 (61.6%)	52(51.5%)	41.9-61.0%	0.232
≥ 25	63 (38.4%)	30(47.6%)	35.8-59.7%	
Trimester				
Second	127 (77.4%)	65(51.2%)	42.6-59.7%	0.314
Third	37 (22.6%)	17(45.9%)	31.0-61.6%	
Gravidity				
1	71 (43.2%)	32(45.1%)	34.0-56.6%	
2	48 (29.3%)	26(54.2%)	40.3-67.4%	1.223
≥3	45 (27.4%)	24(53.3%)	39.1-67.1%	
Parity				
0	87 (53.0%)	43(49.4%)	39.2-59.7%	0.024
≥1	77 (47.0%)	39(50.6%)	39.7-61.5%	
Miscarriage history				
0	122 (74.4%)	57(46.7%)	38.1-55.5%	2.048
≥1	42 (25.6%)	25(59.5%)	44.5-73.0%	

Note: 1 denotes percentage based on total sample size 164, 2 denotes percentage based on each group sample size. CI denotes Confidence Interval, LB denotes Lower Bound, UB denotes Upper Bound.

Using the same statistical method and procedure as in the sunscreen use section, there was no statistically significant difference at the level 0.05 in all factors on the daily dietary vitamin D intake.

A binary logistic regression was conducted to assess whether there were any significant changes from the bivariate analyses after controlling for covariates. Two variables, current employment status and miscarriage history(p < 0.2 from bivariate analysis), and four variables, age group, resident region, pre-pregnancy BMI and gravidity picked from literature, were regarded as more important factors of daily dietary vitamin D intake and were entered in this model simultaneously. The results are shown in Table 4.19.

Table 4.19 Binary logistic regression for daily dietary vitamin D intake (N=164)

Independent variable	**B**	**Wald χ^2**	**OR**	**95%CI LB-UB**	**Pvalue**
Age group (years)					
≥35	-0.203	0.210	0.816	0.342, 1.946	0.647
30-34	-0.072	0.037	0.930	0.446, 1.940	0.847
<30	Reference	0.210			0.900
Resident region	-0.418	1.459	0.658	0.334, 1.297	0.227
Current employment					
Full-time	0.212	0.244	1.237	0.533, 2.871	0.031
Part-time	1.070	4.661	2.915	1.104, 7.699	0.621
Others	Reference	5.315			0.070
Gravidity					
≥3	-0.342	0.316	0.711	0.216, 2.337	0.574
2	-0.044	0.011	0.956	0.416, 2.201	0.917
1	Reference	0.357			0.837
Pre-pregnancy BMI	0.383	1.190	1.467	0.737, 2.918	0.275
Miscarriage history	0.853	2.494	2.347	0.814, 6.769	0.114

Note:CI denotes Confidence Interval, LB denotes Lower Bound, UB denotes Upper Bound.

As can be seen from Table 4.19, after adjustment, no statistically significant independent factors were detected. Although the current employment status was not detected as a significant factor overall, compared to those women who were staying at home (doing home duties or on maternity leave), the odds of those who were still working full-time was 1.237 times (95% CI: 0.533-2.871) higher for vitamin D intake from food.

4.5.2 Vitamin D Supplement

4.5.2.1 Description of vitamin D supplement

According to *Question 44*, on the vitamin D supplementation chart, the everyday dose of vitamin D from supplements in the previous month was calculated. Of the whole population (N = 164), 22.6% of pregnant women were not taking any vitamin D supplements. Among 77.4% of women who were taking vitamin D supplements, the minimum dose of vitamin D was 150 IU per day and the maximum dose was 5,000 IU per day, with a mean dose of 575.7 IU per day(SD=797.98, 95% CI: 452.63-698.71) and a median dose of 500 IU per day, respectively. Approximately half (46.3%) of the pregnant women in this whole population (N=164) were taking 500IU per day of vitamin D supplements. Only 18.3% of whole sample were taking more than 500 IU per day and 12.8% were taking less than 500IU per day, except the pregnant women who were not taking any vitamin D supplements at all. There were 13.4% of women taking 1,000 IU per day or more vitamin D supplements, with 6.7% who were on a 2000 IU or over dose of vitamin D supplements every day (see Figure 4.4).

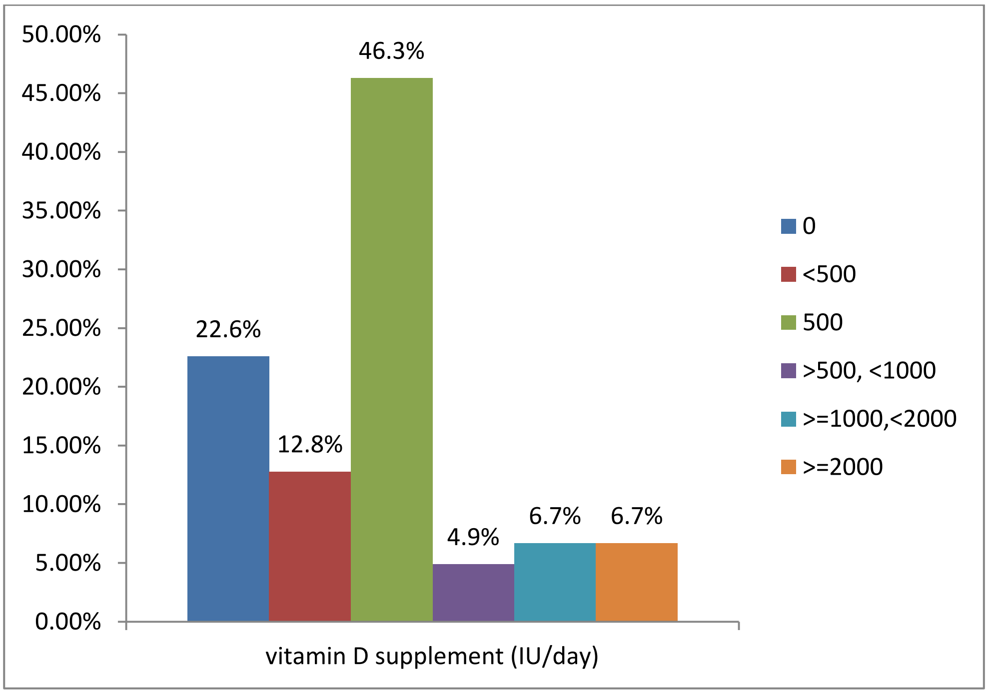


Figure 4.4 The distribution of women taking vitamin D supplements

4.5.2.2 Factors influencing vitamin D supplement

Nearly half of all women were taking 500 IU per day of vitamin D supplements, so they were re-categorised into two groups, women taking < 500 IU per day group (including those not taking any vitamin D supplements at all) and women taking ≥ 500 IU per day group. Then the different demographic and obstetrical characteristics that may impact on the participants' choices were explored. All of the independent variables were categorised into either two or three groups, as previously, and the dependent variable was daily vitamin D supplements of< 500 IU per day or ≥ 500 IU per day (see Table 4.20).

Table 4.20 Factors and daily vitamin D supplements

Factors	N (%[1])	N (%[2])vitamin D supplement "≥500IU/day"	95% CI[2] (LB-UB)	χ^2 value
Age group (years)				
< 30	58 (35.4%)	34(58.6%)	45.8-70.4%	1.673
30-34	68 (41.4%)	45(66.2%)	54.3-76.3%	
≥35	38 (23.2%)	27(71.1%)	55.2-83.0%	
Country of birth				
Australia	134 (81.7%)	86(64.2%)	55.8-71.8%	0.066
Non-Australia	30 (18.3%)	20(66.7%)	48.8-80.8%	
Residence region				
Northern	98 (59.8%)	55(56.1%)	46.3-65.5%	7.718**
Southern	66 (40.2%)	51(77.3%)	65.8-85.7%	
Current employment				
Full-time	85 (51.8%)	57(67.1%)	56.5-76.1%	
Part-time	38 (23.2%)	22(57.9%)	42.2-72.1%	1.000
Others	41 (25.0%)	27(65.9%)	50.5-78.4%	
Educational level				
Under university	50 (30.5%)	34(68.0%)[a,b]	54.2-79.2%	7.268*
Bachelor	72 (43.9%)	39(54.2%)[b]	42.7-65.2%	
Postgraduate	42 (25.6%)	33(78.6%)[a]	64.1-88.3%	
Season				
Winter	107 (65.2%)	66(61.7%)	52.2-80.3%	1.174
Spring+Summer	57 (34.8%)	40(70.2%)	57.3-80.5%	

Factors	N (%[1])	N (%[2])vitamin D supplement "≥500IU/day"	95% CI[2] (LB-UB)	χ^2 value
Skin colour				
Fair	104 (63.4%)	71(68.3%)	58.8-76.4%	1.643
Medium+Olive	60 (36.6%)	35(58.3%)	45.7-69.9%	
Skin burn capacity				
Burn within ½ hour	56 (34.1%)	37(66.1%)	53.0-77.1%	3.157
Burn in ½ - 1 hour	48 (29.3%)	35(72.9%)	59.0-83.4%	
Burn after 1 hour	60 (36.3%)	34(56.7%)	44.1-68.4%	
Pre-pregnancy BMI				
< 25	101 (61.6%)	62(61.4%)	51.6-70.3%	1.213
≥ 25	63 (38.4%)	44(69.8%)	57.6-79.8%	
Trimester				
Second	127 (77.4%)	84(66.1%)	57.5-73.8%	0.560
Third	37 (22.6%)	22(59.5%)	43.5-73.7%	
Gravidity				
1	71 (43.2%)	43(60.6%)	48.9-71.1%	
2	48 (29.3%)	31(64.6%)	50.4-76.6%	1.341
≥3	45 (27.4%)	32(71.1%)	56.6-82.3%	
Parity				
0	87 (53.0%)	56(64.4%)	53.9-73.6%	0.006
≥1	77 (47.0%)	50(64.9%)	53.8-74.7%	
Miscarriage history				
0	122 (74.4%)	74(60.7%)	51.8-68.9%	3.299
≥1	42 (25.6%)	32(76.2%)	61.5-86.5%	

Note: 1 denotes percentage based on total sample size 164, 2 denotes percentage based on each group sample size. * denotes p value < 0.05, ** denotes p value < 0.01. a,b denote statistical significance from each other group underlying one category. CI denotes Confidence Interval, LB denotes Lower Bound, UB denotes Upper Bound.

Using the same statistical method and procedure as in the sunscreen use section, resident region and educational level were detected as having statistically significant differences between groups at the 0.05 level. More pregnant women (proportion=77.3%, 95% CI: 65.8-87.5%) living in Southern Australia took vitamin D supplements ≥ 500 IU per day than women living in Northern Australia (proportion=56.1%, 95% CI: 46.3-65.5%, p=0.005). A total statistical significance (P=0.026) was found in women with three different educational levels. The Bonferroni method z-test for comparing proportions indicated that significantly more pregnant women took vitamin D supplements ≥ 500 IU per day who had a postgraduate degree (proportion=78.6%, 95% CI: 64.1-88.3%) than those with bachelor's degree (proportion=54.2%, 95% CI: 42.7-65.2%), but there was no statistical significance either between women with the "under university" educational level (proportion=68.0%, 95% CI: 54.2-79.2%) and those with a bachelor's degree, or between women with an "under university" educational level and those with a postgraduate degree.

A binary logistic regression was conducted to assess whether there were any significant changes from the bivariate analyses after controlling for covariates. Five variables, resident region, educational level, skin colour, skin burn capacity and miscarriage history ($p < 0.2$ from bivariate analysis), and one variable from literature, pre-pregnancy BMI, were regarded as more important factors of daily vitamin D supplementation and were entered in this model simultaneously. The results are shown in Table 4.21.

Table 4.21 Binary logistic regression for vitamin D supplement (N=164)

Independent variable	**B**	**Wald χ^2**	**OR**	**95%CI LB-UB**	**P-value**
Resident region	-0.955	6.408	0.385	0.184, 0.806	0.011*
Educational level					
Under university	-0.870	2.831	0.419	0.152, 1.154	0.092
Bachelor	-1.067	5.313	0.344	0.139, 0.852	0.021
Postgraduate	Reference	5.390			0.068
Skin colour	0.157	0.129	1.170	0.496, 2.762	0.720
Skin burn capacity					
Burn after 1 hour	-0.193	0.154	0.825	0.314, 2.169	0.696
Burn in ½ -1 hour	0.533	1.288	1.738	0.679, 4.276	0.256
Burn within ½ hour	Reference	2.461			0.292
Pre-pregnancy BMI	-0.131	0.119	0.877	0.416, 1.849	0.730
Miscarriage history	0.687	2.381	1.988	0.831, 4.757	0.123

Note:CI denotes Confidence Interval, LB denotes Lower Bound, UB denotes Upper Bound. * denotes p value < 0.05.

As can be seen from Table 4.21, after adjustment, only the resident region was statistically significant on daily vitamin D supplementation. There were fewer pregnant women living in Northern Australia taking vitamin D supplement ≥ 500 IU per day than those in Southern Australia (OR=0.399, 95% CI: 0.189-0.842, p=0.016). Although the educational level was not detected as being a significant factor overall, compared to those with a postgraduate degree, pregnant women with a bachelor's degree were less likely to take vitamin D supplement ≥ 500 IU per day (OR=0.343, 95% CI: 0.138- 0.852, p=0.021).

4.6 ASSOCIATIONS BETWEEN KNOWLEDGE/ATTITUDE AND BEHAVIOURS

4.6.1 The Associations between Knowledge and Behaviours

Using the method that has been described in Chapter 3, a total knowledge of vitamin D score was calculated. The higher the score is, the more knowledge of vitamin D. In this population, the total knowledge of vitamin D score ranged from zero to 11. The mean score was 4.41 (SD=2.52, 95% CI: 4.02-4.80) and the median score was 4.0. The data were roughly normally distributed.

Bivariate correlations were conducted to explore the relationship between the vitamin D related knowledge score and behaviours, which included five variables as explored previously: UV adjusted outdoor time, clothing score, sunscreen use, dietary vitamin D intake and vitamin D supplement. For continuous variables, a Pearson correlation was used and, for categorised variables, a point biserial correlation was used.

Table 4.22 Correlations of vitamin D knowledge score and behaviours

	Vitamin D knowledge score	
	r	**p value**
UV adjusted outdoor time†	-0.037[1]	0.635
Total clothing score	-0.095[1]	0.225
Sunscreen use *(Yes/No)*	-0.008[2]	0.917
Daily dietary vitamin D intake *(< 1.38µg/d or ≥ 1.38µg/day)*	0.056[2]	0.478
Daily vitamin D supplement *(< 500 IU/day or ≥ 500 IU/day)*	0.090[2]	0.253

1 denotes Pearson correlation coefficients, 2 denotes point biserial correlation coefficients. † denotes that analysis was based on ln(UVadjusted time).

As can be seen in Table 4.22, no significant correlations were found between the vitamin D knowledge score and each behaviour.

4.6.2 The Associations between Attitude and Behaviours

Using the method that has been described in Chapter 3, a total attitude to vitamin D score was calculated. The higher the score meant the more positive the attitude to vitamin D. In this population, the attitude toward vitamin D score ranged from three to 15. The mean score was 9.23 (SD=2.225, 95% CI: 8.88-9.57) and the median score was nine. The data was roughly normally distributed.

Bivariate correlations were conducted to explore the relationship between the vitamin D related attitude score and behaviours, which contain five variables as explored previously: UV adjusted outdoor time, clothing score, sunscreen use, dietary vitamin D intake and vitamin D supplement. For continuous variables, a Pearson correlation was used and for categorised variables, a point biserial correlation was used.

Table 4.23 Correlations of vitamin D attitude score and behaviours

	Vitamin D attitude score	
	r	**p value**
UV adjusted outdoor time	-0.041[1]	0.603
Total clothing score	-0.017[1]	0.829
sunscreen use *(No/Yes)*	-0.187[2]	**0.016**
Daily dietary vitamin D intake *(< 1.38µg/d or ≥ 1.38µg/day)*	0.019[2]	0.807
Daily vitamin D supplement *(< 500 IU/day or ≥ 500 IU/day)*	0.087[2]	0.269

1 denotes Pearson correlation coefficients, 2 denotes point biserial correlation coefficients. † denotes that analysis was based on ln(UVadjusted time).

As can be seen in Table 4.23, the vitamin D attitude score had a negative relationship with sunscreen use. Pregnant women who had a more positive attitude to vitamin D were less likely to apply sunscreen (r=-0.187, p =0.016).

4.7 RELATIONSHIPS BETWEEN VITAMIN D RELATED BEHAVIOURS

4.7.1 Relationships between Sun Exposure and Sun Protective Behaviours

4.7.1.1 UV adjusted outdoor time and total clothing score

A Person's correlation was conducted to explore the relationship between the daily UV adjusted outdoor time and the total clothing score. No significant correlation was detected ($r = -0.73$, $p = 0.354$).

4.7.1.2 UV adjusted outdoor time and sunscreen use

An independent samples t test was conducted to explore the relationship between the daily UV adjusted outdoor time and sunscreen use (No/Yes). No significant difference was detected ($t = -0.044$, $p = 0.965$).

4.7.1.3 Total clothing score and sunscreen use

An independent samples t test was conducted to explore the relationship between the total clothing score and sunscreen use (No/Yes). No significant difference was detected ($t = 0.932$, $p = 0.353$).

4.7.2 Relationship between Dietary Vitamin D Intake and Vitamin D Supplement

A chi-square test was conducted to explore the relationship between daily dietary intake (< 1.38 µg/day; ≥ 1.38 µg/day) and vitamin D supplement (< 500 IU/day; ≥ 500 IU/day). No significance was found ($\chi^2 = 0.000$, $p = 1.000$).

4.7.3 Relationships between Sun Related Behaviours and Vitamin D Intake Behaviours

4.7.3.1 UV adjusted outdoor time and dietary vitamin D intake

An independent samples t test was conducted to explore the relationship between the daily UV adjusted outdoor time and dietary vitamin D intake (< 1.38 µg/day; ≥ 1.38 µg/day). No significant difference was detected ($t = 0.160$, $p = 0.873$).

4.7.3.2 UV adjusted outdoor time and vitamin D supplement

An independent samples t test was conducted to explore the relationship between the daily UV adjusted outdoor time and vitamin D supplement (< 500 IU/day; ≥ 500 IU/day). Even though there was no statistical significance ($t = 1.888$, $p = 0.061$), the p value was close to the significant level of < 0.05. In vitamin D supplement < 500 IU per day group, the mean UV adjusted outdoor time was 88.04 minutes per day (SD = 2.14, 95% CI: 72.10 – 107.50). In the vitamin D supplement ≥ 500 IU per day group, the mean UV adjusted outdoor time was 65.75 minutes per day (SD = 2.81, 95% CI: 53.87 – 80.24). There was a trend that women taking vitamin D supplements of< 500 IU per day had a longer UV adjusted outdoor time than women taking vitamin D supplements of ≥500 IU per day.

4.7.3.3 Total clothing score and dietary vitamin D intake

An independent samples t test was conducted to explore the relationship between the total clothing score and dietary vitamin D intake (< 1.38 μg/day; ≥ 1.38 μg/day). No significant difference was detected ($t = -0.094$, $p = 0.925$).

4.7.3.4 Total clothing score and vitamin D supplement

An independent samples t test was conducted to explore the relationship between the total clothing score and vitamin D supplement (< 500 IU/day; ≥ 500 IU/day). A statistical significance was detected ($t = -2.122$, $p = 0.035$). In the vitamin D supplement < 500 IU per day group, the mean clothing score was 7.60 (SD = 1.08, 95% CI: 7.31 – 7.88). In the vitamin D supplement ≥ 500 IU per day group, the mean clothing score was 7.96 (SD = 1.02, 95% CI: 7.76 – 8.16). Therefore, pregnant women who were taking vitamin D supplements of< 500 IU per day group covered themselves less with clothing than women on ≥ 500 IU per day.

4.7.3.5 Sunscreen use and dietary vitamin D intake

A chi-square test was conducted to explore the relationship between sunscreen use (No/Yes) and daily dietary intake (< 1.38 μg/day; ≥ 1.38 μg/day). No significance was found ($\chi^2 = 0.390$, $p = 0.532$).

4.7.3.6 *Sunscreen use and vitamin D supplement*

A chi-square test was conducted to explore the relationship between sunscreen use (No/Yes) and vitamin D supplement (< 500 IU/day; ≥ 500 IU/day). No significance was found ($\chi^2 = 0.053$, $p = 0.817$).

In summary of the relationships among these vitamin D related behaviours, a significant association was found that pregnant women who were taking vitamin D supplements of< 500 IU per day had a higher clothing score than women on ≥ 500 IU per day. Also, a trend was detected that women taking a vitamin D supplement of < 500 IU per day had a longer UV adjusted outdoor time than women taking a vitamin D supplement of ≥500 IU per day.

PART C: Pregnancy Outcomes and Associations with Maternal Vitamin D Related Behaviours during Pregnancy

The results in this part were from the follow-up survey completed by women from the first survey in their early postpartum period.

4.8 PREGNANCY OUTCOMES

From an initial total of 164 participants who were involved in the first survey, 133 women took part in the follow-up survey. This made the response rate 80.6%, which is considered a relatively high response rate. Among these 133 women, the minimum gestational age was 33.14 weeks and the maximum was 43 weeks. The mean gestational age was 39.40 weeks (SD=1.49), with 39.43 weeks for the median gestational age. Only five (3.8%) and one (0.8%) had pre-term births (less than 37 weeks of gestational age) and post-term births (more than 42 weeks of gestational age), respectively. One in three (33.1%) underwent a caesarean section, while most of the women (66.9%) had a vaginal birth. Only four (3%) and five (3.8%) reported that they had had gestational diabetes or preeclampsia, respectively. When asked about weight gain during the whole pregnancy, three women (2.3%) did not weigh themselves, one (0.8%) woman reported that she had lost 4 kg and four (3.0%) indicated that they did not gain any weight during pregnancy. Among the women who reported that they had gained weight, the weight ranged from 1.0 kg to 30.0 kg, but the majority of women (68.4%) had gained between 10 kg and 20 kg. One woman reported that she had given birth to twins, a boy and a girl, but the other 132 women all had singletons. Thus, there were a total of 134 newborn infants. The numbers were almost equal for girls and boys (49.3% versus 50.7%). The birth weight of the newborn infants ranged from 1,820grams to 4,830grams, and the birth lengths ranged from 29centimetres to 57centimetres, with head circumferences from 30centimetres to 38centimetres (see Table 4.24).

Table 4.24 Pregnancy outcomes

Variable[1]	N (%)	Variable[2]	N (%)
Delivery type		**Sex**	
Caesarean	44(33.1%)	*Boy*	68(50.7%)
Vaginal	89(66.9%)	*Girl*	66(49.3%)
GDM		**Birth weight**	
No	129(97.0%)	*<2500g*	2(1.5%)
Yes	4(3.0%)	*2500g-4000g*	109(81.3%)
Preeclampsia		*>4000g*	23(17.2%)
No	128(96.2%)	**Birth length**	
Yes	5(3.8%)	*<50cm*	30(22.4%)
Gestational age		*≥50cm*	104(77.6%)
< 37 weeks	5(3.8%)	**Head circumference**	
37-42 weeks	125(93.9%)	*<33cm*	9(6.7%)
>42 week	3(2.3%)	*33-37cm*	119(88.8%)
Weight gain		*>37cm*	6(4.5%)
≤ 0 kg	5(3.8%)	**Apgar score in 1 minute**	
1.0-9.9 kg	25(18.8%)	*≤3*	0(0.0%)
10-20 kg	89(66.9%)	*4-6*	5(3.7%)
>20 kg	11(8.3%)	*7-10*	129(96.3%)
Missing	3 (2.2%)	**Apgar score in 5 minutes**	
		≤3	0(0.0%)
		4-6	1(0.7%)
		7-10	133(99.3%)

1 is based on sample size 133, 2 is based on sample size 134

4.9 VITAMIN D STATUS DURING PREGNANCY

There were 45 (33.8%) women whom reported that they had had a vitamin D test during their pregnancy and 10 women indicated that they had the test twice or more. Two time periods were most frequently mentioned for the time of doing a vitamin D test, at about eight weeks and at about 28 weeks of pregnancy. However, most women did not know their accurate vitamin D levels. Three women indicated that their vitamin D status was low and one woman was right in the middle of the normal range being advised by their obstetricians. The lowest vitamin D level was 19 nmol/L, but the highest was 101 nmol/L among the 13 women who could give their vitamin D levels (see Table 4.25).

Table 4.25 Thirteen participants' vitamin D statuses

Participant's No.	Vitamin D levels (nmol/L)	Location	Season of testing
1	85 @ 8 weeks	South Australia	Summer
2	56 @ 28 weeks	South Australia	Autumn
3	39 @ 28 weeks	ACT	Winter
4	62 @ 17 weeks, 101 @ 32 weeks	Victoria	Winter/Spring
5	53 @ 8 weeks	Victoria	Autumn
6	46 @ 7 weeks, 50 @ 20 weeks	New South Wales	Autumn/Winter
7	51 @ 8 weeks	New South Wales	Winter
8	85 @ 34 weeks	South Australia	Summer
9	72 @ 8 weeks	Victoria	Winter
10	19 @ 12 weeks	Victoria	Winter
11	20 @ 10 weeks	Victoria	Winter
12	55 @ 16 weeks	Queensland	Spring
13	55 @ 8 weeks, 75 @ 28 weeks	Victoria	Winter/Summer

Among these vitamin D levels, three results were under 50 nmol/L, eight results were between 50 and 75 nmol/L and only four reached 75 nmol/L and above.

4.10 MATERNAL VITAMIN D RELATED BEHAVIOURS DURING PREGNANCY AND PREGNANCY OUTCOMES

In the previous results in part A, five vitamin D related behaviours were explored: UV adjusted outdoor time, total clothing score, sunscreen use, dietary intake of vitamin D and vitamin D supplement. In this section, the relationship between the five behaviours and pregnancy outcomes, maternal delivery type and weight gain, baby gestational age, birth weight, birth length and head circumference, are assessed. One woman and her babies were excluded in the next analysis because she gave birth to twins. Thus, 132 mother-child pairs were evaluated.

Among the 132 women, their age at delivery ranged from 22 years old to 43 years old, with a mean age of 31.6 ± 4. 1 years old. The age group distribution was 29.5% < 30 years old, 44.0% between 30 and 34 years old, and 26.5% ≥ 35 years old. The majority of them (82.6%) were Australian born. Over half (61.4%) were from

Queensland, while a total of 37.9% were from Southern Australia, for example, New South Wales, South Australia and Victoria. For the educational background, 47.0% had attained a bachelor's degree, 24.2% had a postgraduate degree and the rest (28.8%) had received an "under university" level of education, but at least some high school education. Half of them (54.5%) were first time mothers. There were no differences in these components between women in the baseline survey and the follow-up survey (all $p > 0.05$).

With regard to pregnancy outcomes, 9.8% gave birth in winter, 40.9% were in spring, 36.4% in summer and 12.9% in autumn.

Two thirds (66.7%) were vaginal births while the rest (33.3%) had caesarean sections.

One woman lost 4 kilograms during her whole pregnancy, the rest gave a positive weigh gain, but there were three missing thses data. On average, the weight gain in the women was 13.5 ± 6.2 kg, with the maximum being 30 kg.

The gestational age ranged from 33.14 to 43.00 weeks, with a mean gestational age of 39.40 ± 1.49 weeks. Most (95.4%) were full term babies, with 3.8% pre-term and 0.8% post-term.

The lightest birth weight was 1,820 grams and the largest was 4,830 grams, with a mean weight 3560 ± 514 grams.

Neonatal birth length ranged from 29 centimetres to 57 centimetres, and the average birth length was 51.05 ± 2.96 centimetres.

For the head circumference, the difference was not significant, from 30 centimetres to 38 centimetres, with 34.73 ± 1.62 centimetres on average.

Table 4.26 Descriptions of six pregnancy outcomes for 132 mother-child pairs

		N (%)
Delivery type	*Caesarean*	44(33.3%)
	Vaginal	88(66.7%)
		Mean ± SD (range)
Gestational age *(weeks)*		39.40 ± 1.49 (33.14 - 43.00)

Weight gain *(kg)*	13.5 ± 6.2 (-4 - 30)*
Birth weight *(g)*	3,560 ± 514 (1,820 – 4,830)
Birth length *(cm)*	51.05 ± 2.96 (29 - 57)
Head circumference *(cm)*	34.73 ± 1.62 (30 - 38)

* Three missing cases

For better discovery of the relationship between maternal vitamin D related behaviour and pregnancy outcomes, daily UV adjusted outdoor time was divided into three categories: Group One = <60 minutes per day, Group Two = ≥ 60, < 120 minutes per day and Group Three = ≥120 minutes per day. The total clothing score was divided into three categories: Group One = ≥5.7, < 6.9; Group Two = ≥6.9, < 8.1 and Group Three = ≥8.1, ≤9.3. Sunscreen use: "Yes" group and "No" group. Dietary vitamin D intake: Group One =<1.38 μg per day and Group Two = ≥1.38 μg per day. Vitamin D supplement: Group One =<500 IU per day and Group Two = ≥500 IU per day.

4.10.1 Maternal Vitamin D Related Behaviours and Delivery Type

The impact on delivery type of five maternal vitamin D related behaviours during pregnancy was explored. All independent variables were categorised into either two or three groups, as previously. The dependent variable was delivery type, which was categorised into two groups: "vaginal birth" group and "caesarean birth" group. Therefore, chi-square tests were conducted to compare the vaginal birth ratio in different groups of each independent variable (see Table 4.27).

Table 4.27 Maternal vitamin D related behaviours and delivery type (N=132)

Behaviour	N (%[1])	Vaginal birth N(%[2])	95% CI[2] (LB-UB)	χ^2 value
UV adjusted outdoor time (minutes/day)				
< 60	49 (37.1%)	25(51.0%[a])	37.5-64.4%	**10.097***
60-119.99	40 (30.3%)	33(82.5%[b])	68.1-91.3%	
≥120	43 (32.6%)	30(69.8%[a,b])	54.9-81.4%	
Total clothing score				
<6.9	26 (19.7%)	19(73.1%)	53.9-86.3%	0.708
6.9-8.09	51 (38.6%)	34(66.7%)	53.0-78.0%	
≥8.1	55(41.7%)	35(63.6%)	50.4-75.1%	
Sunscreen use				
No	73(55.3%)	47(64.4%)	52.9-74.4%	0.383
Yes	59 (44.7%)	41(69.5%)	56.9-79.7%	
Dietary vitamin D intake (µg/day)				
<1.38	66 (50.0%)	49(74.2%)	62.6-83.3%	3.409
≥1.38	66 (50.0%)	39(59.1%)	47.0-70.1%	
Vitamin D supplement (IU/day)				
<500	48 (33.3%)	32(66.7%)	52.5-78.3%	0.000
≥500	84 (66.7%)	56(66.7%)	56.1-75.8%	

Note: 1 denotes percentage based on total sample size 132, 2 denotes percentage based on each group sample size. * denotes p<0.05. CI denotes Confidence Interval, LB denotes Lower Bound, UB denotes Upper Bound.

As can be seen from Table 4.27, among the five maternal vitamin D related behaviours during pregnancy, only UV adjusted outdoor time was detected as being statistically significant on delivery type ($p = 0.006$). The Bonferroni method z-test for comparing any differences between the three groups of UV adjusted outdoor time indicated that women with a UV adjusted outdoor time of ≥ 60 minutes per day, but <120 minutes per day (95% CI: 68.1-91.3%) had a higher vaginal birth ratio than women with UV adjusted outdoor time of < 60 minutes per day (95% CI: 37.5-64.4%), but there was no difference in the ratio from women with even more UV adjusted outdoor time ≥ 120 minutes per day (95% CI: 54.9%-81.4%).

4.10.2 Maternal Vitamin D Related Behaviours and Weight Gain

The impact of five maternal vitamin D related behaviours during pregnancy on the participants' weight gain was explored. All independent variables were categorised into either two or three groups as previously. The dependent variable was weight gain in continual data, which was roughly normally distributed. Therefore, one-way ANOVA or independent samples t tests were conducted to compare the weight gain in different groups of each independent variables (see Table 4.28). There were three missing cases in weight gain data, thus, the sample size was 129.

Table 4.28 Maternal vitamin D related behaviours and weight gain (N=129)

Behaviour	N (%[1])	Mean (kg)	95% CI (LB-UB)	Test value
UV adjusted outdoor time (minutes/day)				
< 60	48 (37.2%)	14.6	13.0-16.2	F=1.241
≥60,<120	39 (30.2%)	12.9	11.0-14.8	
≥120	42 (32.6%)	12.7	10.5-15.0	
Total clothing score				
<6.9	25 (19.4%)	13.9	11.5-16.3	F=0.422
≥6.9,<8.1	50 (38.7%)	13.9	12.3-15.5	
≥8.1	54 (41.9%)	12.9	11.0-14.8	
Sunscreen use				
No	73(56.6%)	12.9	11.4-14.4	t=-1.201
Yes	56(42.4%)	14.2	12.7-15.8	
Dietary vitamin D intake (µg/day)				
<1.38	64 (49.6%)	12.7	11.2-14.2	t=-1.387
≥1.38	65 (50.4%)	14.2	12.7-15.8	
Vitamin D supplement (IU/day)				
<500	47 (36.4%)	14.0	12.0-15.9	t=0.683
≥500	82 (63.6%)	13.2	11.9-14.5	

Note: 1 denotes percentage based on sample size 129. CI denotes Confidence Interval, LB denotes Lower Bound, UB denotes Upper Bound.

As can be seen from Table 4.28, among the five maternal vitamin D related behaviour during pregnancy, none were statistically significant on maternal weight gain.

4.10.3 Maternal Vitamin D Related Behaviours and Gestational Age

The impact of five maternal vitamin D related behaviours during pregnancy on gestational age was explored. All independent variables were categorised into either two or three groups as previously. The dependent variable was gestational age in continual data, which was roughly normally distributed. Therefore, one-way ANOVA or independent samples t tests were conduct to compare the gestational age in different groups of each independent variable (see Table 4.29).

Table 4.29 Maternal vitamin D related behaviours and gestational age (N=132)

Behaviour	N (%)	Mean (weeks)	95% CI (LB~UB)	Test value
UV adjusted outdoor time (minutes/day)				
< 60	49 (37.1%)	39.03	38.60-39.47	F=2.441
≥60,<120	40 (30.3%)	39.65	39.16-40.14	
≥120	43 (32.6%)	39.58	39.16-40.02	
Total clothing score				
<6.9	26 (19.7%)	39.46	39.81-40.11	F=0.29
≥6.9,<8.1	51 (38.6%)	39.37	39.01-39.73	
≥8.1	55(41.7%)	39.41	38.97-39.85	
Sunscreen use				
No	73(55.3%)	39.29	38.91-39.67	t=-0.986
Yes	59 (44.7%)	39.55	39.21-39.88	
Dietary vitamin D intake (μg/day)				
<1.38	66 (50.0%)	39.32	38.95-39.69	t=-0.646
≥1.38	66 (50.0%)	39.49	39.12-39.85	
Vitamin D supplement (IU/day)				
<500	48 (33.3%)	39.10	38.63-39.56	t=-1.803
≥500	84 (66.7%)	39.58	39.27-39.89	

Note: CI denotes Confidence Interval, LB denotes Lower Bound, UB denotes Upper Bound.

As can be seen from Table 4.29, among the five maternal vitamin D related behaviours during pregnancy, none were statistically significant on gestational age.

4.10.4 Maternal Vitamin D Related Behaviours and Birth Weight

The impact of five maternal vitamin D related behaviours during pregnancy on neonatal birth weight were explored. All independent variables were categorised into either two or three groups as previously. The dependent variable was birth weight in continual data, which was roughly normally distributed. Therefore, one-way

ANOVA or independent samples t tests were conducted to compare birth weights in different groups of each independent variable (see Table 4.30).

Table 4.30 Maternal vitamin D related behaviours and birth weight (N=132)

Behaviour	N (%)	Mean (g)	95% CI (LB-UB)	Test value
UV adjusted outdoor time (minutes/day)				
< 60	49 (37.1%)	3,468.65	3,341.94-3,595.37	F=0.163
≥60,<120	40 (30.3%)	3,517.58	3,344.08-3,691.07	
≥120	43 (32.6%)	3,702.09	3,534.66-3,869.52	
Total clothing score				
<6.9	26 (19.7%)	3,591.04	3,433.23-3,748.84	F=2.617
≥6.9,<8.1	51 (38.6%)	3,575.51	3,425.56-3,725.46	
≥8.1	55(41.7%)	3,529.80	3,380.45-3,679.15	
Sunscreen use				
No	73(55.3%)	3,564.07	3,440.64-3,687.49	t=0.113
Yes	59 (44.7%)	3,553.90	3,432.84-3,683.96	
Dietary vitamin D intake (μg/day)				
<1.38	66 (50.0%)	3,480.33	3,365.22-3,595.44	t=-1.785
≥1.38	66 (50.0%)	3,638.71	3,504.00-3,773.42	
Vitamin D supplement (IU/day)				
<500	48 (33.3%)	3,485.52	3,322.54-3,648.50	t=-1.253
≥500	84 (66.7%)	3,601.81	3,496.95-3,706.67	

Note: CI denotes Confidence Interval, LB denotes Lower Bound, UB denotes Upper Bound.

As can be seen from Table 4.30, among the five maternal vitamin D related behaviours during pregnancy, none were statistically significant on neonatal birth weight.

4.10.5 Maternal Vitamin D Related Behaviours and Birth Length

The impact of five maternal vitamin D related behaviours during pregnancy on neonatal birth length were explored. All independent variables were categorised into either two or three groups as previously. The dependent variable was birth length in continual data, which was roughly normally distributed. Therefore, one-way ANOVA or independent samples t tests were conducted to compare birth lengths in different groups of each independent variable (see Table 4.31).

Table 4.31 Maternal vitamin D related behaviours and birth length (N=132)

Behaviour	N (%)	Mean (cm)	95% CI (LB-UB)	Test value
UV adjusted outdoor time (minutes/day)				
< 60	49 (37.1%)	51.22	50.57-51.88	F=2.029
≥60,<120	40 (30.3%)	50.30	49.07-51.53	
≥120	43 (32.6%)	51.56	50.75-52.36	
Total clothing score				
<6.9	26 (19.7%)	51.27	50.37-52.17	F=0.257
≥6.9,<8.1	51 (38.6%)	51.18	50.52-51.84	
≥8.1	55(41.7%)	50.84	49.83-51.84	
Sunscreen use				
No	73(55.3%)	51.15	50.34-51.97	t=0.113
Yes	59 (44.7%)	50.93	50.37-51.49	
Dietary vitamin D intake (µg/day)				
<1.38	66 (50.0%)	50.82	49.90-51.73	t=-1.785
≥1.38	66 (50.0%)	51.29	50.81-51.73	
Vitamin D supplement (IU/day)				
<500	48 (33.3%)	50.69	49.57-81.81	t=-1.253
≥500	84 (66.7%)	51.26	50.76-51.76	

Note: CI denotes Confidence Interval, LB denotes Lower Bound, UB denotes Upper Bound.

As can be seen from Table 4.31, among the five maternal vitamin D related behaviours during pregnancy, none were statistically significant on neonatal birth length.

4.10.6 Maternal Vitamin D Related Behaviours and Head Circumference

The impact of five maternal vitamin D related behaviours during pregnancy on neonatal head circumference was explored. All independent variables were categorised into either two or three groups as previously. The dependent variable was head circumference in continual data, which was roughly normally distributed. Therefore, one-way ANOVA or independent samples t tests were conducted to compare the head circumferences in different groups of each independent variable (see Table 4.32).

Table 4.32 Maternal vitamin D related behaviour and head circumference (N=132)

Behaviour	N (%)	Mean (cm)	95% CI (LB-UB)	Test value
UV adjusted outdoor time (minutes/day)				
< 60	49 (37.1%)	34.61	34.14-35.08	F=2.888
≥60,<120	40 (30.3%)	34.38	33.86-34.89	
≥120	43 (32.6%)	35.19	34.71-35.66	
Total clothing score				
<6.9	26 (19.7%)	34.85	34.23-35.46	F=0.127
≥6.9,<8.1	51 (38.6%)	34.75	34.29-35.20	
≥8.1	55(41.7%)	34.65	34.20-35.11	
Sunscreen use				
No	73(55.3%)	34.79	34.39-35.20	t=0.530
Yes	59 (44.7%)	34.64	34.26-35.02	
Dietary vitamin D intake (μg/day)				
<1.38	66 (50.0%)	34.68	34.32-35.05	t=-0.322
≥1.38	66 (50.0%)	34.77	34.34-35.20	
Vitamin D supplement (IU/day)				
<500	48 (33.3%)	34.67	34.21-35.12	t=-0.325
≥500	84 (66.7%)	34.76	34.40-35.12	

Note: CI denotes Confidence Interval, LB denotes Lower Bound, UB denotes Upper Bound.

As can be seen from Table 4.32, among the five maternal vitamin D related behaviours during pregnancy, none were statistically significant on neonatal head circumference.

To summarise the relationships between maternal vitamin D related behaviours during pregnancy and pregnancy outcomes, no significant associations were found, except one—that women with UV adjusted outdoor time of ≥ 60 minutes per day, but < 120 minutes per day had a higher vaginal birth ratio than women with UV adjusted outdoor time of < 60 minutes per day.

4.11 MATERNAL ATITUDES AND PRACTICE OF SUN EXPSOURE AND VITAMIN D REGARDING THE NEW INFANT

4.11.1 Maternal Attitudes and Practice for the New Infant

Concerning feeding the newborn offspring, the majority of the mothers (81.2%) were using breast milk only, while 6.0% used formula milk only and 12.8% of the mothers chose both breast milk and formula milk.

Regarding the mothers' knowledge about vitamin D in breast milk and infant formulate, 8.3% of the mothers thought that formula milk contains more vitamin D, approximately half of the mothers (48.1%) chose breast milk as having more vitamin D, while 9.8% and 33.8% said equal or similar and unsure, respectively.

Only 24.1% of mothers stated that they had received any educational material about vitamin D during pregnancy. The majority (63.2%) recalled that they had not been provided with advice concerning vitamin D, while 12.8% reported "can't remember" whether they had or not been provided with such educational material.

Over half of the mothers either disagreed (41.7%) or strongly disagreed (14.4%) with the statement "your baby need extra vitamin D in the form of drops or supplements", but only 2.3% and 1.5% chose "agree" and "strongly agree", respectively. The rest of them remained either neutral or unsure (17.4% versus 22.7%).

When asked, "Do you think it is a good idea to intentionally sun your baby to get adequate vitamin D", more mothers agreed (25.8%), with 1.5% strongly agreed. However, there were 36.4% and 9.1% choosing "disagree" and "strongly disagree", respectively, and 17.4% and 9.8% remaining "neutral" and "unsure", respectively.

When the participants were asked: "How long would you like to sun your baby each day?'', no one chose "over 45 minutes". Most of them (91.7%) preferred "< 15 minutes" per day and 8.3% chose "15 to 30 minutes" per day. All of them, except two, indicated that they would like to take their baby out either before 10 am (65.2%) or after 2 pm (33.3%).

The majority of mothers (66.7%) endorsed the use of sun protection on their baby when going outside, with 26.5% mothers saying “It depends” and 1.5% reporting “Don’t know yet”. Very few mothers (5.3%) chose “No, I won’t”.

Regarding protecting their babies from the sun, 90.2% of mothers would use clothing, 53.8% would use sunscreen and 87.1% would use shade. Sunglasses were not popular, with 82.6% reporting that they would not use sunglasses on their babies.

4.11.2 Associations between Maternal Behaviours to Themselves and Their Attitudes and Practice to Their New Infants Regarding Vitamin D and Sun Exposure

The associations of five maternal vitamin D related behaviours during pregnancy with the participants’ attitudes and practices towards the new infants regarding vitamin D and sun exposure were explored. All independent variables were categorised into two or three groups as previously. The dependent variables were maternal attitudes and practices towards the new infant regarding vitamin D and sun exposure, which were all categorised into two groups: “Agree/Disagree” or “Yes/No”. Binary logistic regression tests were conducted (see Table 4.33).

Table 4.33 Associations between maternal vitamin D related behaviours to themselves and their attitudes and practices towards the new infant

	Do you think your baby needs extra vitamin D in the form of drops or supplements				**Do you think it is a good idea to intentionally sun your baby to get adequate vitamin D**				**Will you use protection for your baby when taking him/her outside**			
	Agree n (%)	**Disagree n (%)**	**OR (95% CI)**	**P-value**	**Agree n (%)**	**Disagree n (%)**	**OR (95% CI)**	**P-value**	**Yes n (%)**	**No n (%)**	**OR (95% CI)**	**P-value**
Total	5 (3.8)	127 (96.2)			36 (27.3)	96 (72.7)			88 (66.7)	44 (33.3)		
UV adjusted outdoor time (minutes/day)				0.580				0.189				0.082
<60	3 (6.1)	46 (93.9)	1		12 (24.5)	37 (75.5)	1		35 (71.4)	14 (28.6)	1	
≥60,<120	1 (2.5)	39 (97.5)	0.365 (0.037-3.647)		8 (20.0)	32 (80.0)	1.827 (0.744-4.485)		30 (75.0)	10 (25.0)	0.460 (0.194-1.089)	
≥120	1 (2.3)	42 (97.7)	0.929 (0.056-15.360)		16 (37.2)	27 (62.8)	2.370 (0.880-6.387)		23 (53.5)	20 (46.5)	0.383 (0.151-0.975)	
Total clothing score				0.662				0.851				0.931
<6.9	1 (3.8)	25 (96.2)	1		6 (23.1)	20 (76.9)	1		17 (65.4)	9 (34.6)	1	
≥6.9,<8.1	1 (2.0)	50 (98.0)	1.442 (0.143-14.573)		14 (27.5)	37 (72.5)	1.368 (0.463-4.035)		35 (68.6)	16 (31.4)	1.003 (0.376-2.674)	
≥8.1	1 (5.5)	52 (94.5)	2.885 (0.290-28.66)		16 (29.1)	39 (70.9)	1.084 (0.465-2.528)		36 (65.5)	19 (34.5)	0.866 (0.385-1.950)	
Sunscreen use				0.490				0.454				
No	2 (2.7)	71 (97.3)	1		18 (24.7)	55 (75.3)	1		47 (64.4)	26 (35.6)	1	0.536
Yes	3 (5.1)	56 (94.9)	1.902 (0.307-11.775)		18 (30.5)	41 (69.5)	1.341 (0.622-2.892)		41 (69.5)	18 (30.5)	1.260 (0.606-2.621)	

	Do you think your baby needs extra vitamin D in the form of drops or supplements				Do you think it is a good idea to intentionally sun your baby to get adequate vitamin D				Will you use protection for your baby when taking him/her outside			
	Agree n (%)	**Disagree n (%)**	**OR (95% CI)**	**P-value**	**Agree n (%)**	**Disagree n (%)**	**OR (95% CI)**	**P-value**	**Yes n (%)**	**No n (%)**	**OR (95% CI)**	**P-value**
Dietary vitamin D intake (µg/day)				0.651				0.435				1.000
<1.38	3 (4.5)	63 (95.5)	1		20 (30.3)	46 (69.7)	1		44 (66.7)	22 (33.3)	1	
≥1.38	2 (3.0)	64 (97.0)	0.656 (0.106-4.061)		16 (24.2)	50 (75.8)	0.736 (0.341-1.589)		44 (66.7)	22 (33.3)	1.000 (0.485-2.062)	
Vitamin D supplement (IU/day)				0.451				0.971				0.701
<500	1 (2.1)	47 (97.9)	1		13 (27.1)	35 (72.9)	1		33 (68.8)	15 (31.2)	1	
≥500	4 (4.8)	80 (95.2)	2.350 (0.255-21.653)		23 (27.4)	61 (72.6)	1.015 (0.457-2.253)		55 (65.5)	29 (34.5)	0.862 (0.404-1.840)	

Agree includes strongly agree and agree; Disagree includes strongly disagree, disagree, neither agree nor disagree and unsure.
Yes includes Yes, I think so. No includes No, I won’t, It depends,Don’t know yet.

As can be seen from Table 4.33, there were no associations found between the five maternal vitamin D related behaviours during pregnancy and their attitudes and practices towards the new infant regarding vitamin D and sun exposure. Generally, women who had longer UV adjusted outdoor times, lower clothing scores no sunscreen use, lower vitamin D intake from foods or lower vitamin D intake from supplements did not show more concerns about vitamin D supplements and sun exposure of their new infants. Very few mothers were concerned about their new infants needing extra vitamin D. Most of the mothers were more likely to protect their new infants from sun exposure, thus there were no significant associations between the mothers' behaviour versus how she treated her infant.

Chapter 5: Discussion

This chapter presents a discussion of the evidence found in the study results and a comparison to the existing literature. The chapter will begin with a discussion of results from pregnant women's demographic characteristics, followed by a discussion of the results of their vitamin D related behaviours and influencing factors. The pregnancy outcomes and relationships with maternal vitamin D related behaviours will also be discussed in this chapter.

5.1 SAMPLE CHARACTERISTICS

The participants of this study were mostly between the ages of 30 and 34 years at the time of enrolment, which is consistent with data from the Australian Bureau of Statistics reporting that, in 2009, fertility levels are highest among women aged 30 to 34 years. Fewer people (18%) were born overseas in the current study, compared with 27% of the estimated resident population being born overseas in 2011, according to data from the Australian Bureau of Statistics, but the country components are similar, with the United Kingdom and New Zealand being the two countries providing the most overseas-born residents.

The pregnant women in current study are from Australia nationwide, even though over half are from Queensland, which is not surprising as the study site is in Brisbane, Queensland, and more intensive recruitment strategies were applied in this state. However, these women are relatively highly educated; 43.9% with a bachelor's degree, plus 25.6% with a postgraduate degree. Most of them were working professionally. As this is a web-based study, only women who could access the Internet and were able to operate a computer were expected to be involved in this study, so it is not surprising that participation through the Internet resulted in an overrepresentation of higher educational and occupational levels.

Additionally, it is possible that a group with better vitamin D awareness are more motivated to participate.

The participation rate was less than expected at the beginning, but once consent had been given, the women were motivated, which helped with a good retention rate of participants.

5.2 SUN EXPOSURE AND PROTECTIVE BEHAVIOURS

Exposure to sunlight is essential to good health, especially to obtain adequate vitamin D, which is known as the 'sunshine vitamin', as it is mainly produced in the skin by exposure to UVB radiation from sunlight (Holick, 2008). However, exposure to sunlight also causes many adverse effects, such as eye damage, skin damage, such as wrinkles and freckles, and it is a major risk factor for skin cancer (Moyal, 2012). About 99% of non-melanoma skin cancers and 95% melanomas were caused by sun exposure in Australia, the principal country of the incidence rate of skin cancer in the world (Armstrong, 2004). Due to having the highest incidence rate of skin cancer, since the early 1980s, mass media campaigns and programs have promoted sun protection and the awareness of skin cancer, as produced by the Australian government. However, such strict sun avoidance and sun protective procedures to prevent skin cancer may also induce the health risk of vitamin D deficiency.

A high prevalence of vitamin D deficiency in pregnant women has been reported in Australia. Bowyer *et al*,(2009) found that 15% of 971 pregnant women in south-eastern Sydney were vitamin D deficient (defined as 25(OH)D ≤25 nmol/L). Another study, investigating 330 pregnant women in rural Victoria, showed that 25.8% of the participants had 25(OH)D levels of less than 50 nmol/L (Teale & Cunningham, 2010).

The vitamin D related behaviours, including sun exposure and protective behaviours, in this particular population have not been well studied to date. This section aims to provide evidence to assess sun exposure and sun protective behaviours among pregnant women in Australia and to detect subgroups at higher risk that may be unaware of vitamin D deficiency issues. The findings can be used as baseline measures for future behavioural interventions for vitamin D deficiency prevention targeted at pregnant women.

5.2.1 Outdoor Time

Humans obtain vitamin D mainly by cutaneous synthesis through UV radiation (Prentice *et al.*, 2008). For most individuals, about 90% of circulating levels of 25(OH)D are derived from sun exposure (Holick, 2003). The time spent outdoors is an important factor in determining a human's exposure to sunlight, which, in turn, impacts on individual vitamin D statuses.

In this study, the length of time spent in the sun every hour from 5 am to 7 pm was surveyed; a first for pregnant women in Australia. Generally, the participants spent 86.35± 58.86 minutes per day in the sun during the daytime. This is similar to a European study that showed that the average outdoor time was 90 minutes per day among adults from seven European cities (Rotko *et al.*, 2000). Godar*et al.*(2011) also revealed that the outdoor time of adults in the USA was roughly 90 to 100 minutes per day. A study from Australia reported that 42% of participants spent over 120 minutes per day in the sun and 30% spent between 60 and 120 minutes per day in the sun among 144 adults from a tropical Australian community (Nowak et al., 2011), which is greater than in this study.

In this study's population group, women spent more time outdoors daily on weekends than on weekdays. Further, on weekdays, pregnant women spent more time every hour in the sun after 2 pm than before 10 am. Possible reasons for this might be that the majority of participants were still working full-time at enrolment, almost all of them were working mainly indoors, therefore, they stayed inside longer when working on weekdays than they did on weekends and, also, more outdoor activities were undertaken after work on weekdays than during working time. Therefore, the pattern of sun exposure during three separate time periods is different on weekdays to weekends.

On weekends, women spend the greatest amount of outdoor time every hout during the middle of the day (from 10 am to 2 pm), followed by outdoor time every hour after 2 pm, and lastly, by time spent outdoors every hour before 10am. An explanation for this finding could be that Australians prefer to do outdoor activities during the day on weekends, such as going to the beach, eating out and group social occasions, consequently, they spend more time in the sun during the middle of the day.

In their study, Dobbinson*et al*.(2008)found that Australian adults spent an average of 110 minutes outdoors during the peak UV period from 10 am to 2 pm on summer weekends, which is much longer than the time spent outdoors in this study's population. On weekends, the average outdoor time for pregnant women in Australia, during the peak UV period from 10 am to 2 pm, was only 29.24 minutes in this study. Unfortunately, comparable data are lacking for the other time periods.

The strength of UV radiation has an effect on the production of vitamin D in our skin, so, taking into this account, UV adjusted outdoor time was applied in this study when exploring the association between influencing factors and outdoor time. In this study, UV adjusted outdoor time was found to be influenced by educational levels and parity. Even adjusted by other covariates, both of those variables were still significant. Pregnant women with a bachelor's degree had more UV adjusted time than those with a postgraduate degree. This finding is confirmed by a previous study, which concluded that educational levels were linked to sun exposure (El-Hajj Fuleihan, 2009). However, those with an "under university" education level did not show any difference in UV adjusted outdoor time from women either with a bachelor's degree or with a postgraduate degree. One possible explanation is the relatively small sample size in this study, making it less powerful in finding significant differences. The current finding of educational variation in UV adjusted outdoor time might explain, at least partly, the similarity between this and a previous Australian study showing that rates of vitamin D deficiency and insufficiency were greater in Australian adults with a higher level of education (Daly et al., 2012) because they had less UV adjusted outdoor time.

Multiparous women are found to have increased UV adjusted outdoor time over nulliparous women. It is speculated that multiparous women have other children to look after; with children, outdoor activities increase, as a prior study found that women with children participated in significantly more physical activity outdoors than women without children (Sjogren, Hansson, & Stjernberg, 2011).

While the literature reports that young adults spent more hours of sun exposure compared with those of older ages (Nikolaou et al., 2009), age is not significant in UV adjusted outdoor time in this study, perhaps because there is little variation in age among the participants. Previous research showed that there is a seasonal change in outdoor activities, usually increasing in warmer climates and decreasing in colder temperatures (Wolff & Fitzhugh, 2011), which reflects a shorter outdoor time in winter than in other seasons. Inconsistently, no seasonal variation is found in the current study, possibly due to the limited sample size and the consequent lack of power, or maybe because the seasonal temperature changes are not so obvious in Australia, as to change outdoor activities.

5.2.2 Clothing

Levels of UVB radiation reaching the sites of vitamin D synthesis are further attenuated by other factors, such as clothing and sunscreen, which are called 'sun protective behaviours'(Tsiaras & Weinstock, 2011).

The amount of skin exposed to the sun is important. Exposure of the whole body versus only the face, hands and arms has been associated with notable differences in vitaminD synthesis (Misra et al., 2008).The larger the body surface area exposed to sunlight, the more the vitamin D produced by the skin. Therefore, clothing is a significant inhibitor of vitamin D production (Perampalam et al., 2011). For example, a fully clothed infant without a hat requires four times as much sun exposure to achieve similar 25(OH)D concentrations as an infant in only a nappy(Specker *et al.*, 1985). Women who wear concealing clothing, often for religious or cultural reasons, have an increased prevalence of vitamin D deficiency (Grover *et al*., 2001; Diamond *et al*., 2002). Grover *et al.*(2001) conducted a study of 82 veiled and dark-skinned pregnant women in Melbourne, and found that the majority (80%) were vitamin D deficient (<22.5 nmol/L). A cross-sectional study in south-western Sydney, investigating Muslim women aged 20 to 65 years living in an urban community found that 68.1% were vitamin D deficient (<30 nmol/L) (Diamond *et al.*, 2002).

As clothing has been part of the sun protection strategy to prevent skin cancer for many years in Australia, from this study, the success of the efforts can be seen. Relatively high rates of using clothing to cover the body surface area when going outside are observed in this population.

Interestingly, not many participants of this study wore any kind of head cover when going outside. The proportion of hat wearers is similar to a previous study in the USA; 68% white, 69% Hispanic and 63% black Americans rarely wore a hat when going outside (Linos et al., 2012).A prior Australian study showed that hat wearing among Australian adults was about 20%, which is even less than this study's population (Smith *et al.*, 2002).

In this study, one third of participants chose to always wear a shirt with long sleeves when outside and approximately 40% always wore long pants as well. The proportion of those wearing long-sleeved tops in this study is higher than in another Australian study, which had a general population with only 15% of females wearing long-sleeved tops in 2001 (Dobbinson *et al.*, 2002).

Even though 65% women were recruited in winter, the majority of them still put their sunglasses on when going outdoors. This finding is consistent with Dobbinson and colleagues' study (2002) showing that 59% of females responded that they wore sunglasses outside.

In this study, a total clothing score to represent the percentage of body surface area being covered by clothing was calculated. The higher the score, the larger the body surface area covered by clothing. For example, a total clothing score value of 6.0 means that 60% of the body surface area is covered by clothing. On the other hand, 40% of the body surface area was exposed to the sun (skin exposure). In this study, the mean skin exposure is about 22%, which does not ensure vitamin D sufficiency (Perampalam et al., 2011). Perampalam*et al.*(2011) also reported in their study that the skin exposure for pregnant women in Canberra and Campbelltown, Australia, ranged from 19 to 27%, which is consistent with this study's results.

With regard to clothing influencing factors, as expected, compared to women living in Northern Australia, pregnant women living in Southern Australia cover themselves more when going outside. In winter, women wear more than in spring or summer. This clothing pattern is related to ambient temperature. At cold temperatures, people prefer to wear more clothes for comfort, exposing less skin are to the air (Engelsen, 2010). In the winter season, and in Southern Australia, the temperature is relatively lower, thus women put more clothes on to keep warm.

5.2.3 Sunscreen Use

There is great concern that skin cancers are caused by sun exposure, and photo-protection with sunscreen has been recommended to avoid this risk (Green et al., 1999). Although the benefits of sunscreen for protection from sunburn and skin damage to reduce skin cancer is remarkable, the possibility of simultaneously decreasing vitamin D synthesis has arisen (Matsuoka *et al.*, 1988).This is because sunscreen absorbs UVB light and prevents it from reaching and entering the skin, consequently, it causes inadequate sunlight exposure. A sunscreen with a sun protection factor (SPF) 15 (applied correctly) can decrease the ultraviolet dose to relevant skin structures by 98% (Matsuoka *et al.*, 1987). Therefore, it has been suggested that the use of sunscreen to avoid skin damage may also put certain sectors of the population at risk of vitamin D deficiency. A study in the USA, investigating 20 long-term sunscreen users, found that their mean serum 25(OH)D level was 40 nmol/L, while it was 91 nmol/L in 20 age- and sun-exposure-matched controls (Matsuoka *et al.*, 1988).

On the other hand, a woman's skin may become more sensitive to sunlight during pregnancy, partly due to the change in hormone levels (Barankin, Silver, & Carruthers, 2002). For example, melasma, known as 'the mask of pregnancy', which is a pigmentary disorder typically found on the face, can affect up to 50 to 70% of pregnant women (Moin, Jabery, & Fallah, 2006). Sun exposure can worsen the severity of melasma, thus, sunscreen use is commonly recommended to control and prevent this dermatosis, and several studies have confirmed its effectiveness (Abarca et al., 1987; Lakhdar et al., 2007).

It is speculated that sunscreen is largely applied by pregnant women, especially in Australia where there is plenty of sunlight. In this study, 48.8% women reported that they use sunscreen. Given that the majority of participants were mainly indoor workers, this proportion is likely representative of those who participated.

Sunscreen use is one of the commonly reported sun protective behaviours around the world. Similar to these findings, a Melbourne study found that the prevalence of use of sunscreen use was 46% in females (Dobbinson *et al.*, 2002). However, the proportion is higher than in one USA study with only 37.1% of women reporting the use of sunscreen (Buller et al., 2011). Another study in the USA showed that 34.6% of pregnant women applied sunscreen (Merewood et al., 2010). As is well known, Australia has higher ambient UV radiation than USA/Europe, so people here tend to apply sunscreen more.

The pregnant women in this study were more likely to apply sunscreen to the body surfaces that are more frequently exposed to sunlight, such as the face (98.8%), neck (90%) and forearms (75%). Surfaces such as the trunk and thighs, which are usually covered by clothing, are applied with sunscreen the least.

A sunscreen's SPF is effectively a measure of its capacity to protect against UV-induced erythema. Even though this study's findings reveal that over half of pregnant women do not apply sunscreen and the majority of women who use sunscreen apply it only once a day, this is less than the recommended guide of applying sunscreen every two hours during sun exposure.

Taking into account the limited time in the sun of these women, as explored above, it can still be seen that there is a higher proportion of adherence of sunscreen use among these women than other populations. Moreover, the analysis in this study shows that the vast majority of pregnant women use sunscreen with SPF > 30, but other studies from Europe, as well as the USA, show a higher proportion of people who use a lower SPF (Robinson *et al.*, 1997). It is speculated that the stronger ambient UV radiation in Australia has possibly strengthened the use of sunscreen in the population, compared with populations living in lower ambient UV radiation environments.

With regard to the influencing factors of sunscreen use, not surprisingly, fewer pregnant women in Southern Australia apply sunscreen than those in Northern Australia. In winter, less pregnant women use sunscreen than in spring or summer. As described in the literature review, the strength of ambient UV radiation is related to latitude and season (Holick, 2007). It decreases at a greater latitude location and in winter. Accordingly, the ambient UV radiation in Australia is stronger in the northern area (closer to the equator and with a lower latitude) than in the southern area, and it is also stronger in spring or summer than in winter, therefore, it is understandable that pregnant women exposed to stronger UV radiation are more likely to use sunscreen.

5.2.4 Summary

In this study, pregnant women in Australia are more likely to stay out of the sun, cover their body surfaces with clothing and apply sunscreen. Throughout evolution, humans have depended on the sun for their vitamin D requirement, but the recommendation for the avoidance of all sun exposure has put the world's population at risk of vitamin D deficiency, especially pregnant women, as they need extra vitamin D to support foetal growth (Specker, 2004). These avoiding sun exposure behaviours might partly explain why this population group is particularly vulnerable to vitamin D deficiency. Therefore, pregnant women need to be encouraged to get more sunlight onto their skin.

5.3 VITAMIN D INTAKE

Even though the amount of vitamin D from diet is limited, with increasing use of fortified foods and supplements, as well as reduced sun exposure due to environmental, social or physiological circumstances, dietary compensation must occur to obtain adequate vitamin D for people who cannot produce enough vitamin D cutaneously. In the general population, the importance of vitamin D intake has been identified by several studies, by demonstrating a significant association between vitamin D intake and the reduction in risk of several chronic diseases, including osteoporosis, cancer, rheumatoid arthritis and multiple sclerosis (Feskanich, Willett, & Colditz, 2003; McCullough et al., 2003; Merlino et al., 2004; Munger, 2004).

Additionally, the significance of vitamin D intake during pregnancy has been illustrated by a number of studies, as follows.

In the 1970s, Paunier*et al.*(1978) reported that pregnant women living in high latitudes in winter months with an intake of less than 3.8 μg of vitamin D per day had low serum 25(OH)D levels. Recently, Viljakainen*et al*.(2010) also observed that the total maternal intake of vitamin D during pregnancy was positively linked to serum 25(OH)D status in both the postpartum ($r=0.363$, $p < 0.001$) and umbilical cord ($r=0.340$, $p<0.005$).

Multiple studies have suggested that higher maternal vitamin D intake is associated with increased infant birth size (McGrath et al., 2005; Sabour et al., 2006; Scholl & Chen, 2009). Mannion*et al.*(2006) observed that, for each one μg increase of dietary vitamin D from both food and supplements, birth weight was increased by 11 grams (95% CI: 1.2-20.7g).

A few studies have shown that maternal vitamin D intake may be negatively associated with allergic diseases in childhood (Devereux et al., 2007; Erkkola et al., 2009), demonstrating the potential role of vitamin D in regulating the immune system. Moreover, maternal intake of vitamin D from food or supplementation during pregnancy was negatively associated with the risk of early β cell autoimmunity of offspring in two cohort studies (Brekke & Ludvigsson, 2007; Fronczak et al., 2003).

Thus, vitamin D intake from foods and supplements is more important to public health than was previously thought.

5.3.1 Dietary Vitamin D Intake

As is previously outlined, human beings obtain very limited amounts of vitamin D from food (Holick, 2007), however, what is not known is the importance of this in to human health, especially during pregnancy, a critical period for two. Fronczak*et al.*(2003) found that the maternal intake of vitamin D from foods during pregnancy was associated with a reduced risk of islet autoimmunity appearance in children, after adjusting for HLA genotype, family history of type one diabetes, the presence of gestational diabetes mellitus and ethnicity (adjusted HR=0.37; 95% CI: 0.17–0.78). One population-based cohort study in Finland revealed that the maternal intake of vitamin D from food was negatively related to the risk of asthma (HR=0.80, 95% CI: 0.64-0.99) and allergic rhinitis (HR=0.85, 95% CI: 0.75-0.97) in offspring (Erkkola et al., 2009).

Currently in Australia, oily fish naturally contains vitamin D and appears to be the major dietary source of vitamin D. However, vitamin D fortification is only mandated for margarine and other edible oil spreads and is voluntary for milk products (Nowson & Marherison, 2002). Such restrictive food regulation has led to a considerably less average dietary intake for adults than in countries where more extensive vitamin D fortification is practised, such as the USA (average estimated daily dietary vitamin D intake 2-3 μg versus 3-6 μg) (Nowson et al., 2012).

The average vitamin D intake from food is only 1.89 μg per day in pregnant women in the current study, which is even less than the average intake of the general population in Australia. The overall population based data for females of dietary intakes of vitamin D in Australia are not yet available, however, data from the National Health and Nutrition Examination Survey in the USA, have shown that the average vitamin D intake from foods alone for females in the USA ranged from 3.8 μg per day to 6.9 μg per day (144 – 276 IU per day) (Bailey et al., 2010), which is much higher than this study's result.

A few studies in different countries investigating vitamin D intake during pregnancy also showed a higher dietary vitamin D intake than this study's participants' intake. Scholl *et al.*, (2009) found that the vitamin D intake was 4.81 ± 0.074 μg per day from diet in 2,251 pregnant women in the USA. Carmargo*et al.*(2007) reported in their study that the mean vitamin D intake from food during pregnancy was 5.625 μg per day in eastern Massachusetts, USA. Similarly, in a population of pregnant Finnish women, the mean daily intake of vitamin D was 5.1 μg from food (Marjamäki et al., 2010). More recently, a large observational study in Denmark unveiled that the mean dietary vitamin D intake was 3.56 ± 2.05 μg per day among 68,447 pregnant women (Jensen et al., 2012). A small study in Ireland reported that the median vitamin D intake from food was 2.0 μg per day, 1.9 μg per day and 2.1 μg per day in the first, second and third trimesters, respectively, which is similar to this study. Additionally, the dietary vitamin D intake was 2.26 ± 1.87 μg per day in Iranian pregnant women (Sabour et al., 2006). Only one study showed a lower dietary vitamin D intake, 1.05 ± 0.80 μg per day, in a population of Pakistani pregnant women (Alfaham *et al.*, 1995). Moreover, one Australian study revealed that, in 201 pregnant women from Canberra and Campbelltown, only 12 participants achieved the recommended dietary intake of 10 μg (400 IU) of vitamin D daily (Perampalam et al., 2011).

An extremely low vitamin D diet is observed in this study, probably because there are relatively limited foods rich in vitamin D naturally available and also due to the currently low levels of vitamin D fortification in Australia as previously mentioned (Nowson & Marherison, 2002). Another possible explanation is that not all vitamin D-containing foods were used in the calculations, but just the major vitamin D-containing foods were evaluated and, therefore, the dietary vitamin D intake might be underestimated in this study's population. However, the foods calculated in this study contribute to the major amount of vitamin D from diet, thus, the estimation still reflects the tendency of dietary vitamin D intake in this population, which, generally, is not sufficient in the participants.

One USA study (Scholl & Chen, 2009) suggested that parity, pre-pregnancy BMI and ethnicity were associated with differences in the intake of vitamin D during pregnancy. Moreover, a study from Finland found that a higher intake of vitamin D from food was positively linked with maternal age, educational background, as well as with non-smoking during pregnancy (Marjamäki et al., 2010).

This study failed to discover any influencing factors in relation to dietary vitamin D intake, perhaps owing to the fact that most women in this study had vitamin D intakes from food that were far too low. Also, this study has a lack of power to detect any associations. Therefore, it cannot be ruled out that such associations exist.

5.3.2 Vitamin D Supplement

As there is difficulty obtaining sufficient levels of vitamin D through food or exposure to the sun, most nutritionists recommend taking vitamin D supplements instead. Vitamin D supplements contributed 40% to the total vitamin D intake in USA caucasian women (Park *et al.*, 2001), 49% of Norwegian women (Jorde & Bønna, 2000), and 24% of British women (Henderson et al., 2003).

Javaid*et al.*(2006), in their longitudinal study, found that women taking vitamin D containing supplements during pregnancy had higher median concentrations of 25(OH)D than those who did not (73.25 nmol/L versus 49 nmol/L, p=0.001). Perampalam*et al.*(2011), investigating serum vitamin D status in pregnancy in two Australian populations, showed higher serum vitamin D levels with consumption of ≥500 IU D_3 per day than <500 IU D_3 per day in Australian pregnant women, indicating that vitamin D supplementation is a significant determinant for vitamin D status during pregnancy. Holmes *et al.*(2009) demonstrated similar findings in pregnant women in the United Kingdom. Similar findings have also been reported in the USA (Yu et al., 2009; Bodnar et al., 2007). Vitamin D supplements of 400 IU per day were shown to increase serum 25(OH)D levels by seven nmol per litre(Heaney *et al.*, 2003).

The ability of vitamin D supplements to increase maternal serum concentrations of 25(OH)D may not be sufficient justification to recommend their use. However, the direct benefits of such supplements have been reported by multiple studies. Two trials indicated that pregnant women supplemented with vitamin D had significantly greater average daily weight gains in the third trimester than did unsupplemented controls (Marya et al., 1988; Maxwell et al., 1981). A large study from Norway revealed that the risk of preeclampsia decreased by 27% (OR=0.73, 95% CI: 0.58–0.92) in women supplemented with vitamin D 400–600 IU per day, compared to women without supplements (Haugen et al., 2009). A longitudinal study in the United Kingdom reported that infants born to women with vitamin D supplements of 1000 IU per day during the last trimester of pregnancy gained significantly greater weight than the control group at three, six, nine and 12 months old, respectively(Brooke, Butters, & Wood, 1981). A prospective cohort study in Massachusetts, USA, investigating 1,194 mother-child pairs unveiled that a 100 IU increase in maternal vitamin D intake from supplements was associated with a lower risk of recurrent wheeze in a child (OR=0.82, 95%CI: 0.73 – 0.92) (Camargo et al., 2007).

The amounts of vitamin D from supplements vary a lot, depending on the study population and site. In this study, the average intake of vitamin D from supplements among 164 pregnant women is 12.5 μg per day (500 IU per day), which is higher than the amount in other studies. The amount of vitamin D from supplements in 2,215 low income, minority gravidae from Camden, USA, was 5.50±0.047 μg per day (Scholl & Chen, 2009). Marjamaki*et al.*(2010) observed that the mean daily intake of vitamin D was only 1.3 μg per day from supplements in a population of pregnant Finnish women.

With regard to the vitamin D supplements usage ratio in pregnant women, similar results to a previous study by Viljaka*et al.*(2010), reporting that, in their study, 80% women used vitamin D supplements during pregnancy, were found. There are 77.4% pregnant women in this study reporting the use of any vitamin D containing supplements, but the average vitamin D from supplementation in the former study was only 6.6 ± 4.8 μg per day, lower than that of this study. This proportion of using vitamin D supplements, however, is higher than another study: Only 32% of women were taking vitamin D supplements during pregnancy in Finland (Erkkola et al., 2009). More recently, among 68,447 pregnant Danish women, 67.6% reported the use of vitamin D supplements in any dose, but only 36.9% were at a ≥ 10 μg per day dose, which is the dose now recommended in Denmark for pregnant women, and the mean vitamin D intake from supplements was 5.67 ± 5.20 μg per day (Jensen et al., 2012).

The current Australian guidelines for recommended vitamin D intake are 200 IU daily from birth to 50 years old, 400 IU daily from 51 to 70 years old and 600 IU daily for those over 70 years of age(Lehmann & Meurer, 2010), without specific recommendation for pregnancy and lactation. In earlier this year, a new position statement was released of recommendation vitamin D intake for pregnant women, 600 IU daily for pregnant women is recommended (Paxton et al., 2013). In this study, 77.4% of pregnant women were taking supplements containing any dose of vitamin D, ranging from 150 IU to 5,000 IU.

In this study, the first two brands that most pregnant women chose as prenatal vitamins are Blackmores Pregnancy & Breast-Feeding Gold and Elevit Pregnancy. The former contains 250 IU per capsule with a dosage of two capsules per day, and the latter contains 500 IU per tablet with a dosage of one tablet per day. Therefore, nearly half (46.3%) of the women took 500 IU vitamin D daily. Overall, the proportion of vitamin D intake ≥ 500 IU per day from supplements is 64.6% in this study, which is higher than another Australian study reporting that 41% of pregnant women from Canberra and Campbelltown, Australia, took doses of ≥ 500 IU per day (Perampalam et al., 2011).

Recently, the IOM of the USA issued new guidelines with respect to pregnant women for a vitamin D intake of 600 IU daily, which was based on the amount of intake necessary to sustain circulating 25(OH)D levels over 50 nmol/L (Ross et al., 2011). More recently, a new position statement on vitamin D and health for adults in Australia and New Zealand has been published, in which the recommended vitamin D intakes are 600 IU per day for people aged < 70 years (Nowson et al., 2012). In light of this recommendation, the participants need more vitamin D from supplements to meet the criteria.

Notably, Hollis *et al.*(2011) conducted a randomized, controlled trial. A diverse group of pregnant women living at latitude 32°N at 12 to 16 weeks' gestation received 400, 2,000 or 4,000 IU of vitamin D_3 per day until delivery. This trial found that vitamin D supplementation of 4,000 IU per day for pregnant women, regardless of race or ethnicity, was safe and most effective in achieving vitamin D sufficiency. Hence, there is a greater need to show more robust evidence to make a standard recommendation for vitamin D supplementation in the future.

After adjustment for other covariates, resident region shows statistical significance on daily vitamin D supplement. There are fewer pregnant women living in Northern Australia taking a vitamin D supplement of ≥ 500 IU per day than those in Southern Australia (OR=0.399, 95% CI: 0.189 - 0.842, p=0.016). The underlying reason is not clear.

With regard to educational levels, compared to those with a postgraduate degree, pregnant women with a bachelor’s degree were less likely to take a vitamin D supplement of ≥ 500 IU per day (OR=0.343, 95% CI: 0.138 – 0.852, p=0.021). This result is consistent with Marjamäki*et al.*’s (2010) finding that higher vitamin D intake from supplements in pregnant women were in those with an academic educational background. However, they also revealed, in their study, that a higher vitamin D intake from supplements was found in pregnant women who were expecting their first child and those with a lower BMI, while, in contrast, such associations were not found in the current study. Again, with the limited sample size, these associations cannot be ruled out and should be the focus of the future studies.

5.3.3 Summary

It is acknowledged that this population group is particularly vulnerable to vitamin D deficiency. Vitamin D is found in small quantities in a limited number of foods, including fortified foods (Holick, 2007). Compared to cutaneous synthesis following sun exposure, vitamin D intake through diet (food and supplements) is often thought to exert a minor effect on vitamin D status and human health. However, previous research has shown that vitamin D intake is a potential predictor of circulating levels of 25(OH)D, and especially that the regular use of prenatal multivitamins increases vitamin D levels in pregnant women (Bodnar et al., 2007; Javaid et al., 2006). The importance of vitamin D intake from foods and supplements for maintaining adequate circulating 25(OH)D levels, as well as exerting a positive effect on human health, should not be ignored.

The recommendations for vitamin D intake vary between countries, due to the debate of the definition of optimal vitamin D status and the optimal intake level of vitamin D. Moreover, the intake amount of vitamin D that is suitable for pregnancy has not been quantified for certain yet. But, because the nutrients that pregnant woman gets, should support the two. It is speculated that the vitamin D intake in pregnancy may need to be several times higher than the current recommendation.

Dietary vitamin D intake is very low in the current study population, which underlines the necessity of vitamin D supplementation. Nevertheless, the present results suggest that supplement usage is low at only by 12.5 (500 IU) μg per day on average. Also, 22.6% of pregnant women do not take any vitamin D supplements. The most common pregnancy-specific multivitamins contain relatively low doses of vitamin D. It is suggested, therefore, that there is an urgent need for studies to discover the dietary intake and/or supplementation of vitamin D needed to maintain adequate vitamin D levels in pregnancy. Such evidence could then to be used to underpin guidelines for dietary vitamin D intake and supplement use during this particular period. Further, pregnant women should be informed of suitable food sources and recommended to take correct the supplements of vitamin D to meet their bodily needs.

Multiple studies have shown the relationships between individual characteristics and vitamin D intake during pregnancy. For instance, age was found to be inversely associated with vitamin D intake in a number of studies (Arkkola et al., 2006; Haugen et al., 2008; ; Marjamäki et al., 2010; Mathews et al., 2000), suggesting that younger expectant mothers may be less aware of health matters. Furthermore, compared to multiparous women, nulliparous women are found to be more likely to have sufficient total vitamin D intakes in a study by Jensen *et al.*(2012). In several studies, overweight women have been found to be less likely to have sufficient vitamin D intake and supplementary use (Arkkola et al., 2006; Haugen et al., 2008). The above differences were not seen in this study.

Studies found that smoking status was associated with vitamin D intake, with higher intakes in non-smoking expectant mothers (Jensen et al., 2012). However, due to all participants reporting that they were not smoking during pregnancy in this study, this association was not investigated.

High education was found to be positively associated with vitamin D intake and supplement use in some studies (Arkkola et al., 2006; Haugen et al., 2008; Marjamäki et al., 2010). Women with postgraduate degrees had higher vitamin D supplements in this study, but the difference in dietary vitamin D intake was not apparent.

One study also found a significant association between season and a vitamin D intake of ≥ 10 μg per day, showing higher ORs in summer than in winter (Jensen et al., 2012). The difference is not evident either for dietary intake or supplementary use in the current study.

There is no evidence of an influence of trimester on vitamin D intake for pregnant women, because dietary intake may change over the course of a pregnancy, but these changes are relatively minor (Rifas-Shiman et al., 2006). A significant association between living region and vitamin D supplement use was found, where, in Northern Australia, fewer pregnant women were taking vitamin D supplements of ≥ 500 IU per day than those in Southern Australia. It reflects a regional variation in the awareness of the importance of vitamin D supplementation. However, the underlying reason is unclear and needs further investigation.

5.4 KNOWLEDGE AND ATTITUDES TO VITAMIN D

5.4.1 Knowledge of Vitamin D

The questionnaire contained four open-ended questions assessing the knowledge of vitamin D. For the first question, with regard to the health problems that people may develop if vitamin D is inadequate, the answers were categorised into three major aspects: bone health related problems, non-bone health related problems and others, including "unknown", "not sure" or health problems not related to vitamin D. Not surprisingly, the majority of pregnant women indicated that they know about the links between bone and vitamin D, as the role of vitamin D in bone health has been well established and broadcasted for decades (Holick, 2005). Only approximately one in three could cite at least one non-bone related health problem, such as depression, weakened immune system, heart disease and cancer. It has been gradually recognised that vitamin D might be involved in various health issues besides bone health (Holick, 2008). However, it seems that these novel functions are just restricted to academic society, and have not been popularised very much in communities. A large study investigating urban office workers from Brisbane, Australia, revealed that 31% of its participants did not know the benefits of vitamin D (Vu *et al.*, 2010). Similarly, 29.9% of pregnant women in this study did not know or gave wrong answers to health problems if vitamin D is inadequate.

For the second question, in relation to symptoms and signs of vitamin D inadequacy, due to the large amount of women giving null or non vitamin D related answers, only two categories were set up, "know" and "don't know". The proportion was 50% of women who knew of at least one symptom or sign. Among the positive answers, generalized weakness is mostly mentioned, and bone related symptoms and signs were second. Unexpectedly, half of the women did not know any symptoms or signs of vitamin D deficiency, which is slightly higher than another, non-pregnant, female population in the United Kingdom, of which 45% were not aware of the symptoms of vitamin D deficiency (Alemu & Varnam, 2012).

Comparing the data resulting from the answers to the first two questions in this study, it can be seen that, even though women know some of the health problems when vitamin D is inadequate, a higher proportion of them could not cite any symptoms or signs. It might be possibly assumed that women are less conscious of vitamin D deficiency during pregnancy.

The last two questions are about the ways to acquire vitamin D and the best way to obtain vitamin D, respectively. As mentioned in the literature review, the most common ways can be described in three categories: through sun exposure, food, and supplementation. Nearly all of the women (94.5%) know at least one strategy to obtain vitamin D, with almost half giving any two of these strategies and over one-third giving all three strategies. With regard to the best strategy to acquire vitamin D, excepting the 10.4% giving a null answer, 64.4% chose sun exposure only as the best strategy, while a very limited number of women chose a combination of the three ways. The majority of pregnant women have knowledge of sources of vitamin D and many of them identified sun exposure as the best way to obtain vitamin D.

5.4.2 Attitudes to Vitamin D

Three multiple-choice questions were given to collect participants' attitudes toward vitamin D.

For the first statement, "I need to spend more time in the sun during summer to get enough vitamin D to be healthy", roughly 40% of women gave either a positive response ("strongly agree" or "agree") or a negative response ("disagree" or "strongly disagree") for each answer, and the remaining 20% were neutral.

With regard to, "I worry about getting enough vitamin D", the proportion is similar to the first question, with 39% positive, 43.3% negative and 17.7% neutral.

In the Vu *et al.*(2010) study, 50% of office workers disagreed with the statement, "I am concerned that my current vitamin D level might be too low", and 9% agreed. For the disagreement, the proportion is similar to this study's finding, but a higher proportion of the participants herein agreed that they worry about getting enough vitamin D.

For the statement, "It is more important to stay out of the sun than it is to get enough vitamin D", more women stayed neutral (32.3%), but more women (51.2%) showed a positive attitude to vitamin D by giving a negative answer ("disagree" or "strongly disagree"). It seems that pregnant women have a more positive attitude towards vitamin D, however, this increase is trivial. Generally speaking, with regard to their attitudes to vitamin D, roughly 40% women were positive, another 40%were negative and the rest (20%) were neutral, which indicates that pregnant women in this study have a very ambiguous overall attitude to vitamin D.

5.4.3 Associations between Knowledge/Attitude and Behaviours

According Knowledge-Attitude-Behaviour (KAB) model, knowledge and attitude are considered as perquisites to behavioural performance. Thus, whether better knowledge and more positive attitudes towards vitamin D could lead to better vitamin D related behaviours in pregnant women were tested.

One Dutch study revealed that better knowledge of vitamin D and calcium was associated with both high serum 25(OH)D status and a higher daily dietary calcium intake in older people (Oudshoorn et al., 2012). Unfortunately, no significant correlations were found between knowledge and five vitamin D related behaviours in this study. One attitude-behaviour correlation was observed in this study; that pregnant women with a more positive attitude to vitamin D applied sunscreen less ($r=-0.187$, $p<0.01$).

A study conducted of young women in the USA found no effect of an increased knowledge of vitamin D on dietary intake of vitamin D (Bohaty *et al.*, 2008), which is in accordance with the findings of this study.

In addition, the relationship between knowledge, attitude and behaviour may also be conflicting according to some studies. For example, a study, conducted by Kung and Lee, by telephone interview of Chinese women in Hong Kong about vitamin D knowledge and behaviour related to sunlight, revealed that individuals with the best awareness of the benefits of sunlight and the importance of vitamin D for human health tended to avoid sun exposure the most (Kung & Lee, 2006). Another study by Kim *et al.*(2012) observed that parents who had a stronger belief in sunlight helping the body to produce vitamin D had lower sun exposure. Obviously, there are gaps in knowledge and attitudes to real behavioural performance. Therefore, it is important to identify these gaps by simply improving knowledge and attitudes in an attempt to intervene in behavioural change.

5.5 RELATIONSHIPS BETWEEN VITAMIN D RELATED BEHAVIOURS

Women taking a vitamin D supplement of< 500 IU per day cover themselves less than women with a ≥ 500 IU per day vitamin D supplement. There is a trend ($p = 0.061$, close to significant the level of 0.05) that women taking a vitamin D supplement of< 500 IU per day spend more UV adjusted outdoor time than women taking a vitamin D supplement of ≥ 500 IU per day. Taking the relatively small sample size into account, this relationship might be significant if the sample size is enlarged. These two relationships can be interpreted as women having less vitamin D from supplements, but they would complement it with UVB radiation, and vice versa. There is a counteraction between sun exposure and the use of supplements. Therefore, only using sun exposure and protective behaviours or vitamin D intake to predict vitamin D status is not sufficient and may result in inaccurate estimations.

The result from this study is inconsistent with other research, which found that sunscreen use may cause longer time spent in the sun (Philippe Autier et al., 1999). The participants who reported using sunscreen in the past month do not have longer UV adjusted outdoor time in this study. The possible reason is that the participants unintentionally exposed themselves to the sun, which is represented by sun exposure during daily life activities without a particular intention to obtain a tan or being able to spend a long time in the sun, while the subjects in the previously mentioned study are getting intentional sun exposure. They are looking for a biological effect, and sunbathing is the most typical behaviour for intentional sun exposure (Autier *et al.*, 2007). During intentional sun exposure, people prolong their time in the sun by using sunscreen, but during unintentional sun exposure, sunscreen use would not increase the time spent in the sun (Autier *et al.*, 2007).

5.6 MATERNAL VITAMIN D RELATED BEHAVIOURS DURING PREGNANCY AND PREGNANCY OUTCOMES

As has been pointed out in the literature review, low maternal vitamin D status around pregnancy has been associated with numerous adverse pregnancy outcomes. For example, a case-control study showed a significant association between 25(OH)D concentrations in early pregnancy and subsequent preeclampsia (Bodnar et al., 2007). Another nested case-control study with 953 pregnant women found that, compared to control subjects, women who subsequently developed gestational diabetes had serum 25(OH)D concentrations significantly lower at an average of 16 weeks of gestation (Zhang et al., 2008). In addition, women with 25(OH)D < 37.5nmol per litre were almost four times more likely to have a caesarean birth than women with 25(OH)D ≥ 37.5nmol per litre (adjusted OR=3.84; 95% CI: 1.71 – 8.62) (Merewood *et al.*, 2009). Moreover, several studies have investigated the relationship between maternal vitamin D status during pregnancy and their baby's birth conditions, besides the mother's own effects. A potential negative correlation between maternal vitamin D status and gestation length has been reported (Morley *et al.*, 2006). Leffelaar*et al.*(2010) reported that pregnant women with deficient vitamin D levels (defined as 25(OH)D < 30 nmol/L) had infants with lower birth weights (-144.4grams, 95% CI: -151.2 – -77.6). Knee to heel length was shorter in neonates of mothers with 25(OH)D < 28 nmol/L than in babies whose mothers had higher concentrations during pregnancy (Morley et al., 2006).

An individual's blood vitamin D status depends on the person's sun exposure behaviours, dietary intake and supplementation. In this thesis, this is called "vitamin D related behaviours". Thus, it was hypothesised in the beginning that maternal vitamin D related behaviours during pregnancy might be directly associated with pregnancy outcomes.

A prospective study found a 27% reduction in risk of preeclampsia for pregnant women taking 10 to 15µg per day(400–600IU per day) of vitamin D as compared with no supplements (OR=0.73, 95%CI: 0.58-0.92) (Haugen et al., 2009). This association was not examined in the current study, as only five women of a total of 132 women mentioned that they had this health condition.

In this study, no relationship was found between maternal vitamin D related behaviours during pregnancy and pregnancy outcomes, except that women with UV adjusted outdoor time of ≥ 60 minutes per day, but <120 minutes per day, had a higher vaginal birth ratio than women with a UV adjusted outdoor time of < 60 minutes per day (82.5% versus 51.0%).

McGrath *et al*. (2005) hypothesised that the seasonal variation of neonatal birth size results from sunlight fluctuation, which is subsequently related to maternal vitamin D status during pregnancy. A prospective cohort study observed that maternal UVB exposure in the third trimester is positively related to birth length, whereas it is not associated with birth weight, and, further, that it is related to children's bone size, such as bone mineral content, bone area and bone mineral density, at the age of 9.9 years old (Sayers & Tobias, 2009). In a New Zealand cohort study, the authors revealed that neonatal birth length and weight was strongly associated with the amount of prenatal sunlight exposure in the early months of pregnancy (Waldie *et al.*, 2000). Furthermore, in another birth cohort from New Zealand, the birth weight of infants whose mothers were exposed to peak UV radiation periods during the first trimester of gestation were heavier than those whose mothers experienced less UV radiation periods during the same trimester (Tustin, Gross, & Hayne, 2004). Additionally, another small study, with 326 healthy adolescents and their 204 mothers, was conducted in Lebanon to investigate the impact of maternal veiling during pregnancy on an offspring's bone mass (Nabulsi *et al.*, 2008). The authors revealed that maternal veiling during pregnancy was associated with decreased bone mass at multiple skeletal sites of the study's participants' sons at the age of 13 years. In the current study, maternal UV adjusted outdoor time, total clothing score or sunscreen use was not found to have an effect on neonatal birth weights and birth lengths, largely due to the relatively small sample size.

Inconsistently with a previous study finding that mothers with adequate vitamin D and calcium intake had a greater weight gain during pregnancy (Sabour et al., 2006), this association was not found in this study. The possible reason might be that, in this study's population, vitamin D intake from food was extremely low. Only three women met the currently recommended, adequate intake (AI) of five µg per day in Australia.

No relationship between maternal vitamin D intake from both foods and supplements and neonatal birth size was found. Some findings are consistent with previous research, but some are not. A cross sectional study in Iran of 449 pregnant women at the point of delivery unveiled a significant correlation between the adequate maternal intake of calcium and vitamin D and appropriate birth weight, and, also, an adequate maternal intake of calcium and vitamin D produced higher birth lengths(Sabour et al., 2006). However, Sabour*et al*. (2006) also found no association between maternal calcium and vitamin D intake and neonatal head circumferences, which is in agreement with the results of this study. In summary, in this study, there is a lack of evidence showing the relationships between maternal vitamin D related behaviours and pregnancy outcomes, largely due to the small sample size. However, as a pilot study, these results might stimulate some attention on this subject. Further research is warranted.

5.7 MATERNAL VITAMIN D RELATED BEHAVIOURS DURING PREGNANCY, AND ATTITUDES AND PRACTICES TOWARDS THE NEW INFANTS REGARDING VITAMIN D AND SUN EXPOSURE

The majority of mothers chose to breastfeed, but few were aware that the amount of vitamin D in human breast milk is extremely limited; less than is found in infant formula (Alpert & Shaikh, 2007). Therefore, external supplementation for breast feeding baby is recommendation by American Academic of Pediatrics (Misra et al., 2008). More than half of the mothers reported that they had received no prenatal advice about vitamin D. This lack of knowledge could contribute to the lack of awareness that breast milk is not a good source of vitamin D and that extra vitamin D drops or supplements might be needed for some infants.

Furthermore, given that the skin of newborns is more vulnerable to being sunburnt than that of adults (Giam et al., 1999), and, after more than 20 years of media campaigns promoting skin cancer prevention conducted in Australia (Montague et al., 2001), mothers are more likely to protect the new infants from the sun rather than to expose babies to the sun to acquire vitamin D. This behaviour appeared to be independent of the mothers' own sun exposure and vitamin D intake behaviours.

5.8 COMPARISONS WITH AUSTRALIAN NORMATIVE DATA

As mentioned in Chapter 3, the questionnaires used in this study were adapted from the AusD study, a large study investigating the factors that influence vitamin D production in Australian adults, which was conducted by Professor Michael Kimlin *et al.* between 2008 and 2010. Fieldwork was undertaken at four study sites across Australia, Townsville, Brisbane, Canberra and Hobart. Therefore, the opportunity presented itself to use the preliminary data from the AusD study to compare the participants' vitamin D related behaviours. A subset of 72 non-pregnant females living in Brisbane, aged 19 years to 48 years, from the AusD study was derived to match the participants, most of whom were from Brisbane in Queensland, Australia. Permission for using these preliminary data was obtained from the AusD study chief investigator, Professor Michael Kimlin.

As this is not a case-control study, the two sets of data were not suitable for statistical analysis and they were not adjusted for various factors, such as educational level or season. The major aim of the comparison shown herein is to be instructive for future research and, as such, it is shown how representative the sample is.

In this subset, the median daily outdoor time from 5 am to 7 pm among the childbearing-aged females from the AusD study was 84 minutes, with 72 minutes on weekdays and 109 minutes on weekends, which, while slightly longer, are generally comparable with the outdoor times of the pregnant women in this study, who spent 74 minutes per day of the whole week: 60 minutes per day on weekdays and 90 minutes per day on weekends, respectively. The UV adjusted outdoor time was slightly lower in the pregnant women than the childbearing-aged females (76.5 minutes per day versus 90 minutes per day).

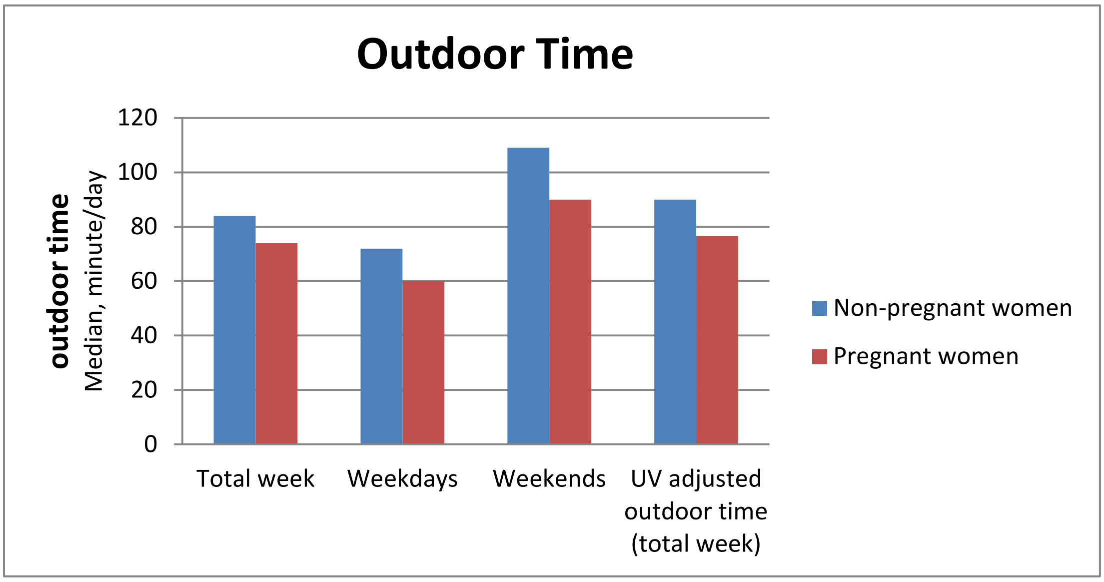


Figure 5.1 Outdoor time

These two populations had a similar pattern on wearing head coverings (including broad-brimmed hats, caps or other kinds of head coverings) and sunglasses when going outside. Wearing a head covering was not a popular fashion among the childbearing-aged females, but wearing sunglasses was. However, based on an inspection of crude percentages, a higher proportion of the pregnant women were more inclined to wear a long-sleeved shirt and long trousers than the childbearing-aged females. There were 58.5% and 76.2% pregnant women choosing to wear long-sleeved shirts and long trousers “always” or “almost always”, or “more than half of the time”, respectively, but only 37.4% and 57.0% of the childbearing-aged females chose these options. Therefore, the pregnant women had a higher mean total clothing score than the childbearing-aged females (7.87 versus 6.91), which interprets to the body surface area being covered by clothing in 78.7% of the pregnant women and in 69.1% of the childbearing-aged females.

In the childbearing-aged females, more than half (62.5%) used sunscreen, while the comparable percentage in pregnant women was somewhat less (48.8%). However, considering the significant influence of residential region on sunscreen use, the pregnant women who were living in Northern Australia, normally in Queensland, had a similar sunscreen use rate (59.8%). Furthermore, the adherence of using sunscreen was also similar in these two populations, in that most of them only applied sunscreen with SPF 30+ and used it once or twice a day, but they used it almost every day.

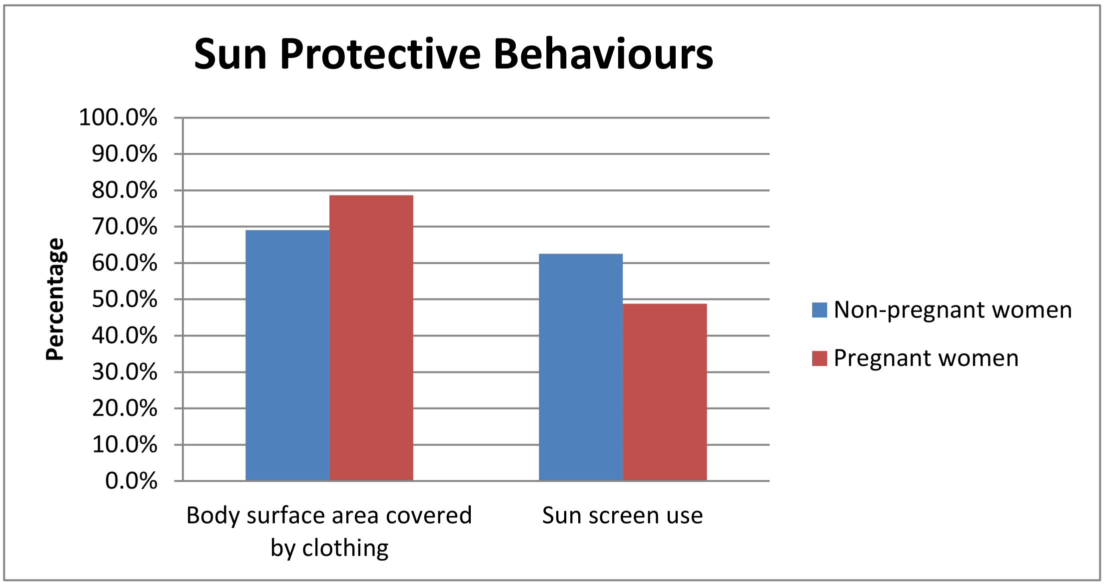


Figure 5.2 Sun protective behaviours

With regard to the vitamin D intake from foods and supplements, a similar intake from foods was found (1.63 µg per day in childbearing-aged females versus 1.38 µg per day in pregnant women). However, more pregnant women (77.4%) took vitamin D containing supplements than the childbearing-aged females (33.3%), as well as a greater amount vitamin D from supplements. The median amount of vitamin D from supplements in the childbearing-aged females was 200 IU per day, while 500 IU per day vitamin D on average was obtained from supplements among pregnant women.

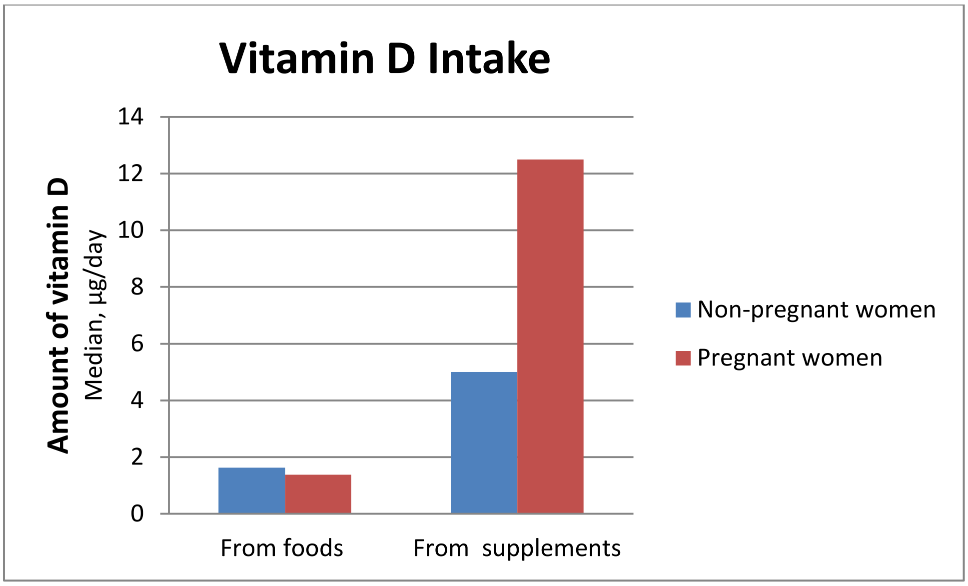


Figure 5.3 Vitamin D intake

In summary, compared with childbearing-aged females from the same location, pregnant women had slightly less outdoor time and more clothing covering than non-pregnant, childbearing-aged females, but both groups were similar in sunscreen use and vitamin D intake from foods. However, a particularly higher vitamin D intake from supplements was found in the pregnant women.

Chapter 6: Conclusion

The purpose of this final chapter is to summarise and integrate the main findings from previous chapters of this study. A discussion of strengths and limitations of the research is offered, followed by implications for public health and future research.

6.1 SUMMARY OF FINDINGS

This study has identified possible explanations that may prevent women in Australia from obtaining adequate vitamin D during pregnancy.

Pregnant women in Australia spend limited time outside. When in the sun, they would like to cover, on average, 78% of the body surface. Half of them use sunscreen to protect their skin, and 30+ is the universal SPF in use.

The amount of vitamin D acquired from food is extremely low among pregnant women in Australia. Even though the proportion of these women taking vitamin D supplements is relatively higher than other populations, there are still over one-fifth going without any vitamin D supplements during pregnancy. In consideration of the dose, according to the latest recommendation from the Institute of Medicine, USA, the daily allowance of vitamin D is 600 IU (15 μg) for people aged one to 70 years, including pregnant women. The participants are short of this recommendation, with only one-third achieving 600 IU per day for vitamin D intake both from foods and supplements.

There are some influencing factors that may affect pregnant women's vitamin D related behaviours, such as educational level, residential region and season. These might be important indicators when screening for pregnant women at risk of vitamin D deficiency in Australia. Furthermore, pregnant women have a relatively good knowledge of vitamin D, even though there is some confusion (knowing of the health problems of vitamin D deficiency, but not being able to cite any symptoms or signs). However, their attitudes to vitamin D are ambiguous, with similar proportions on either positive or negative sides with approximately one-fifth keeping neutral. Additionally, the knowledge and attitudes do not directly result in actual behaviours.

There is a counteraction between sun exposure and vitamin D supplement use among the participants. Pregnant women who take a vitamin D supplement of < 500 IU per day cover themselves less by clothing than women on a dose of ≥ 500 IU per day. Pregnant women taking a vitamin D supplement of < 500 IU per day tend to have longer UV adjusted outdoor times than women on ≥ 500 IU per day. Therefore, only using sun exposure and protective behaviours or vitamin D intake to predict vitamin D status may not be sufficient.

The data lack evidence showing the relationships between maternal vitamin D related behaviours and pregnancy outcomes in this study. However, as mentioned in Chapter 3, the secondary research questions were addressed in an exploratory manner. Taking into account the relatively small sample size, it is likely to be underpowered to detect the relationships. It cannot, therefore, be ruled out that such associations exist. The findings lack the sensitivity needed to fully define the influence of vitamin D status on the course and outcomes of pregnancy. However, as a secondary aim in this study, the interest is in gathering preliminary data, and the resultant data do show some significance to warrant further studies.

6.2 STUDY STRENGTHS AND LIMITATIONS

One of the strengths of this study is that it is believed to be the first study in Australia to investigate pregnant women's vitamin D related behaviours systematically, including sun exposure and protective behaviours, as well as vitamin D intake from both food and supplements. Secondly, by using a web-based survey, a nationwide and diverse group of pregnant women is approached and assessed in this study. Thirdly, UV adjusted outdoor time is applied in the data analysis, which is more accurate when related to vitamin D synthesis. Finally, the study is cost effective, which is suitable for a PhD project.

The study's limitations need to be noted so that the data can be understood correctly.

First, its main limitation is the relatively small sample size. In light of the sample size calculation, as described in Chapter 3, it is sufficient to estimate the mean levels or prevalence of five vitamin D related behaviours with a certain degree of accuracy. However, it is likely to be underpowered in detecting the relationships between these behaviours, influencing factors and other variables. The limited sample size of this study precludes a comprehensive understanding of the factors influencing vitamin D related behaviours, as well as the implications of pregnancy outcomes.

The second limitation is that this study relies on self-reported information. Reports are subject to recall bias and are best thought of as indicating what pregnant women think they did rather than what 'actually happened' last month. It is possible that some individuals incorrectly reported their behaviours, which are subject to recall bias.

Third, the participants of this study generally had a higher educational level, which is not representative of the entire Australian population. It is possible that an awareness of vitamin D benefits might be higher in this particular group. Sun exposure could also be different for this group, as educational levels have been linked to sun exposure (El-Hajj Fuleihan, 2009). Therefore, the generalisability of the study is limited, however, as an exploratory study; the aim to stimulate some attention to this subject has been achieved.

Fourth, a database of all known vitamin D containing diets and supplements in Australia has not been developed. Such a database would enable a more accurate estimate of oral vitamin D intake. Also, the vitamin D amount obtained from food depends on the cooking and feeding methods. However, the latter point is not considered in this study and estimation is relied on, using the mean value of each food type. It is, therefore, uncertain whether the estimated intakes in this study reflect the real intake.

Fifth, there is no control group in this study. Instead the data is compared with that from previous literature. The associations found may have been stronger if this study had been designed as a case control study.

Sixth, the optimal design is to conduct a longitudinal, prospective study and trace women pre-pregnancy to post pregnancy, which could reflect how current vitamin D related behaviours may have changed since the respondents become pregnant.

Therefore, a large-sample-sized, representative, case-controlled and longitudinal study is needed to further investigate vitamin D related behaviours among pregnant women, who are prone to vitamin D deficiency. The data collected here are preliminary and can be used to conduct power analyses for future studies.

6.3 IMPLICATIONS FOR PRACTICE

In recent years, vitamin D has been a focus of growing interest in public health nutrition. Vitamin D insufficiency is common around the world. The reasons might be multifactorial, but probably stem from a combination of decreased dietary intake of vitamin D and decreased sun exposure.

There is no doubt that sun exposure causes health issues, especially it being the main reason for the development of skin cancer. Therefore, excessive sun exposure has to be avoided. However, strict sun avoidance may induce the risk of vitamin D deficiency. Pregnant women have a high prevalence of vitamin D deficiency and inadequate sun exposure, at least partially, contributes to this issue. Media campaigns have highlighted the purported harm of sun exposure by the delivery of "slip, slop, slap" and other messages to the population of Australia. However, in light of the benefits of sun exposure, there is a need to find a balance in order to minimise the risk of skin cancer and maximise vitamin D synthesis from sun exposure. Public health and other intervention strategies to facilitate appropriate sun exposure in this vulnerable population should, therefore, be developed.

It has been suggested that pregnancy is a time to motivate women to improve health maximally. While it is important to be sun safe, it is equally as important to ensure the intake of a regular dose of adequate vitamin D. People can increase their vitamin D intake from both food and supplements, alternatively, while sun exposure is unavailable. Generally, of the pregnant women studied in the present investigation, the overall intake of vitamin D from food was not sufficient. Thus, pregnant women should be informed of suitable food sources, and it would be best to recommend taking the correct supplementary amounts to meet their bodily needs under the guidance of their licensed healthcare provider. Considering its safety, low costs and potentially wide, broad-range beneficial effects on both mothers and offspring, it could lead to a structural measurement and use of vitamin D supplementation in pregnancy.

How to improve the vitamin D status of pregnant women in Australia? The strategies might not be only restricted to sun exposure or vitamin D intake. A combination of multiple strategies might be more practical, with consideration of the availability of sun exposure and dietary sources. Furthermore, consideration of the cautionary guidelines to limit sun exposure to prevent skin cancer, and limited food types containing adequate vitamin D, either naturally or by fortification, it seems that vitamin D supplementation prescribed to pregnant women as routine has a high priority. Future research ought to look at sunlight exposure and supplement use, together with dietary intake and the maternal vitamin D status, in order to decipher how much vitamin D needs to be consumed to reach recommendations.

It is also important to detect and treat vitamin D deficiency in this population. Pregnancy is an opportune time for health care providers to give targeted, practical advice that will help women to better understand the risks associated with being vitamin D deficient. At present, vitamin D screening and supplementation are not routinely offered to all pregnant women. Thus, it is important for health care providers to identify those pregnant women at a higher risk of vitamin D deficiency.

6.4 IMPLICATIONS FOR FUTURERESEARCH

With the mounting evidence that lower levels of vitamin D are associated with an increased risk of adverse pregnancy outcomes, improving the maternal vitamin D status in pregnancy has a tremendous capacity to benefit public health. This study's data adds to the growing body of research supporting the assertion that the current individual lifestyle (low sun exposure and low vitamin D intake) might be directly attributable to the epidemic of vitamin D deficiency during pregnancy in Australia.

Taking into account the limitations of the current study, large-sample-sized, case-controlled studies, with representative populations, are needed in the future to better investigate the potential influencing factors for maternal vitamin D related behaviours during pregnancy and their direct implications for pregnancy outcomes. Meanwhile, an optimal serum vitamin D level during pregnancy has not been determined and remains an area of active research. Additionally, exactly how much sun exposure is needed for maintaining an optimal vitamin D level during pregnancy is not clear. This remains to be elucidated in future studies.

Some pregnant women cannot obtain adequate vitamin D through sun exposure, and limited food sources are available and supplementation seems to be more easily implemented, but how much vitamin D should be recommended to pregnant women is still debated. More studies are needed to provide conclusive evidence on effective, but also safe, doses of vitamin D supplements during pregnancy.

Bibliography

Abarca, J., Odilla Arrollo, C., Blanch, S., & Arellano, G. (1987). Melasma in pregnancy: reduction of its appearance with the use of a broad-spectrum photoprotective agent. *Medicina Cutanea Ibero-Latino-Americana, 15*(3), 199-203.

Adams, J. S., Kantorovich, V., Wu, C., Javanbakht, M., & Hollis, B. W. (1999). Resolution of vitamin D insufficiency in osteopenic patients results in rapid recovery of bone mineral density. *J Clin Endocrinol Metab, 84*(8), 2729-2730.

Agarwal, K. S., Mughal, M. Z., Upadhyay, P., Berry, J. L., Mawer, E. B., & Puliyel, J. M. (2002). The impact of atmospheric pollution on vitamin D status of infants and toddlers in Delhi, India. *Arch Dis Child, 87*(2), 111-113.

Alagöl, F., Shihadeh, Y., Shihadeh, Y., Boztepe, H., Tanakol, R., Yarman, S., et al. (2000). Sunlight exposure and vitamin D deficiency in Turkish women. *J Endocrinol Invest. , 23*(3), 173-177.

Alemu, E., & Varnam, R. (2012). Awareness of vitamin D deficiency among at-risk patients. *BMC Research Notes, 5*(1), 17.

Alfaham, M., Woodhead, S., Pask, G., & Davies, D. (1995). Vitamin D deficiency: a concern in pregnant Asian women. *British Journal of Nutrition, 73*(6), 881-887.

Alpert, P. T., & Shaikh, U. (2007). The effects of vitamin D deficiency and insufficiency on the endocrine and paracrine systems. *Biol Res Nurs, 9*(2), 117-129.

Anderson, P., May, B., & Morris, H. (2003). Vitamin D metabolism: new concepts and clinical implications. *Clin Biochem Rev, 24*(1), 13-26.

Arkkola, T., Uusitalo, U., Pietikainen, M., Metsala, J., Kronberg-Kippila, C., Erkkola, M., et al. (2006). Dietary intake and use of dietary supplements in relation to demographic variables among pregnant Finnish women. *British Journal of Nutrition, 96*(5), 913-920.

Armstrong, B. (2004). How sun exposure causes skin cancer. In D. Hill, J. Elwood & D. English (Eds.), *Prevention of skin cancer*. Dordrecht: Kluwer Academic Publishers.

Arya, V., Bhambri, R., Godbole, M. M., & Mithal, A. (2004). Vitamin D status and its relationship with bone mineral density in healthy Asian Indians. *Osteoporos Int., 15*(1), 56-61.

Autier, P., Boniol, M., & Dore, J. F. (2007). Sunscreen use and increased duration of intentional sun exposure: still a burning issue. *International Journal of Cancer, 121*(1), 1-5.

Autier, P., DorÃ©, J.-F. o., NÃ©grier, S., LiÃ©nard, D. l., Panizzon, R., Lejeune, F. J., et al. (1999). Sunscreen use and duration of sun exposure: a double-blind, randomized trial. *Journal of the National Cancer Institute, 91*(15), 1304-1309.

Bailey, R. L., Dodd, K. W., Goldman, J. A., Gahche, J. J., Dwyer, J. T., Moshfegh, A. J., et al. (2010). Estimation of total usual calcium and vitamin D intakes in the United States. *Journal of Nutrition, 140*(4), 817-822.

Barankin, B., Silver, S. G., & Carruthers, A. (2002). The skin in pregnancy. *Journal of Cutaneous Medicine and Surgery, 6*(3), 236-240.

Benchikhi, H., Razoki, H., & Lakhdar, H. (2002). Sunscreens: use in pregnant women at Casablanca. *Annales de Dermatologie et de Venereologie, 129*(4 Pt 1), 387-390.

Bikle, D. (2009). Nonclassic actions of vitamin D. *J Clin Endocrinol Metab, 94*(1), 26-34.

Bischoff-Ferrari, H. (2009). Vitamin D: what is an adequate vitamin D level and how much supplementation is necessary? *Best Pract Res Clin Rheumatol. , 23*(6), 789-795.

Bodnar, L. M., Catov, J. M., Zmuda, J. M., Cooper, M. E., Parrott, M. S., Roberts, J. M., et al. (2010). Maternal serum 25-hydroxyvitamin D concentrations are associated with small-for-gestational age births in white women. *The Journal of Nutrition, 140*(5), 999-1006.

Bodnar, L. M., Krohn, M. A., & Simhan, H. N. (2009). Maternal vitamin D deficiency is associated with bacterial vaginosis in the first trimester of pregnancy. *J. Nutr., 139*(6), 1157-1161.

Bodnar, L. M., Simhan, H. N., Powers, R. W., Frank, M. P., Cooperstein, E., & Roberts, J. M. (2007). High prevalence of vitamin D insufficiency in black and white pregnant women residing in the Northern United States and their neonates. *J. Nutr., 137*(2), 447-452.

Bohaty, K., Rocole, H., Wehling, K., & Waltman, N. (2008). Testing the effectiveness of an educational intervention to increase dietary intake of calcium and vitamin D in young adult women. *Journal of the American Academy of Nurse Practitioners, 20*(2), 93-99.

Bowyer, L., Catling-Paull, C., Diamond, T., Homer, C., Davis, G., & Craig, M. E. (2009). Vitamin D, PTH and calcium levels in pregnant women and their neonates. *Clinical Endocrinology, 70*(3), 372-377.

Brekke, H. K., & Ludvigsson, J. (2007). Vitamin D supplementation and diabetes-related autoimmunity in the ABIS study. *Pediatr Diabetes, 8*(1), 11-14.

Brooke, O. G., Brown, I. R., Bone, C. D., Carter, N. D., Cleeve, H. J., Maxwell, J. D., et al. (1980). Vitamin D supplements in pregnant Asian women: effects on calcium status and fetal growth. *Br Med J, 280*(6216), 751-754.

Brooke, O. G., Butters, F., & Wood, C. (1981). Intrauterine vitamin D nutrition and postnatal growth in Asian infants. *BMJ (Clinical Research Ed.), 283*(6298), 1024-1024.

Buller, D. B., Cokkinides, V., Hall, H. I., Hartman, A. M., Saraiya, M., Miller, E., et al. (2011). Prevalence of sunburn, sun protection, and indoor tanning behaviors among Americans: review from national surveys and case studies of 3 states. *Journal of the American Academy of Dermatology, 65*(5 Suppl 1), S114-123.

Camadoo, L., Tibbott, R., & Isaza, F. (2007). Maternal vitamin D deficiency associated with neonatal hypocalcaemic convulsions. *Nutr J, 6*, 23.

Camargo, C. A., Jr., Rifas-Shiman, S. L., Litonjua, A. A., Rich-Edwards, J. W., Weiss, S. T., Gold, D. R., et al. (2007). Maternal intake of vitamin D during pregnancy and risk of recurrent wheeze in children at 3 y of age. *Am J Clin Nutr, 85*(3), 788-795.

Carroll, K. N., Gebretsadik, T., Larkin, E. K., Dupont, W. D., Liu, Z., Van Driest, S., et al. (2011). Relationship of maternal vitamin D level with maternal and infant respiratory disease. *American Journal of Obstetrics and Gynecology, 205*(3), 215 e211-217.

Cavalier, E., Delanaye, P., Morreale, A., Carlisi, A., Mourad, I., Chapelle, J. P., et al. (2008). Vitamin D deficiency in recently pregnant women. *Rev Med Liege. , 62*(2), 87-91.
Ceglia, L. (2009). Vitamin D and its role in skeletal muscle. *Curr Opin Clin Nutr Metab Care*.
Centers for Disease Control and Prevention. (2012). Sunburn and sun protective behaviors among adults aged 18-29 years--United States, 2000-2010. *Morbidity and Mortality Weekly Report, 61*(18), 317-322.
Chodick, G., Kleinerman, R. A., Linet, M. S., Fears, T., Kwok, R. K., Kimlin, M. G., et al. (2008). Agreement between diary records of time spent outdoors and personal ultraviolet radiation dose measurements. *Photochemistry and Photobiology, 84*(3), 713-718.
Choi, H. S., Kim, K.-A., Lim, C.-Y., Rhee, S. Y., Hwang, Y.-C., Kim, K. M., et al. (2011). Low serum vitamin D is associated with high risk of diabetes in Korean adults. *The Journal of Nutrition, 141*(8), 1524-1528.
Clemens, T. L., Adams, J. S., Henderson, S. L., & Holick, M. F. (1982). Increased skin pigment reduces the capacity of skin to synthesise vitamin D3. *Lancet, 1*(8263), 74-76.
Clifton-Bligh, R. J., McElduff, P., & McElduff, A. (2008). Maternal vitamin D deficiency, ethnicity and gestational diabetes. *Diabet Med, 25*(6), 678-684.
Cutolo, M., & Otsa, K. (2008). Vitamin D, immunity and lupus. *Lupus, 17*(1), 6-10.
Daly, R. M., Gagnon, C., Lu, Z. X., Magliano, D. J., Dunstan, D. W., Sikaris, K. A., et al. (2012). Prevalence of vitamin D deficiency and its determinants in Australian adults aged 25 years and older: a national, population-based study. *Clinical Endocrinology, 77*(1), 26-35.
DeLuca, H. F. (2004). Overview of general physiologic features and functions of vitamin D. *Am J Clin Nutr, 80*(6), 1689S-1696.
Delvin, E. E., Arabian, A., Glorieux, F. H., & Mamer, O. A. (1985). In vitro metabolism of 25-hydroxycholecalciferol by isolated cells from human decidua. *Journal of Clinical Endocrinology & Metabolism, 60*(5), 880-885.
Delvin, E. E., Salle, B. L., Glorieux, F. H., Adeleine, P., & David, L. S. (1986). Vitamin D supplementation during pregnancy: effect on neonatal calcium homeostasis. *Journal of Pediatrics, 109*(2), 328-334.
Devereux, G., Litonjua, A. A., Turner, S. W., Craig, L. C. A., McNeill, G., Martindale, S., et al. (2007). Maternal vitamin D intake during pregnancy and early childhood wheezing. *Am J Clin Nutr, 85*(3), 853-859.
Diamond, J. (2005). Evolutionary biology: Geography and skin colour. *Nature, 435*(7040), 283-284.
Diamond, T. H., Levy, S., Smith, A., & Day, P. (2002). High bone turnover in Muslim women with vitamin D deficiency. *Medical Journal of Australia, 177*(3), 139-141.
Dobbinson, S., Hill, D., & White, V. (2002). *Trends in sun protection: Use of sunscreen, hats and clothing over the past decade in Melbourne, Australia*. Paper presented at the UV Radiation and its effects Workshop: an update 2002.,
Dobbinson, S., Wakefield, M., Hill, D., Girgis, A., Aitken, J. F., Beckmann, K., et al. (2008). Prevalence and determinants of Australian adolescents' and adults' weekend sun protection and sunburn, summer 2003-2004. *Journal of the American Academy of Dermatology, 59*(4), 602-614.

Dore, J.-F., & Chignol, M.-C. (2012). Tanning salons and skin cancer. *Photochemical & Photobiological Sciences, 11*(1), 30-37.
Dusso, A. S., Brown, A. J., & Slatopolsky, E. (2005). Vitamin D. *Am J Physiol Renal Physiol, 289*(1), F8-28.
Eknoyan, G. (2008). Adolphe Quetelet (1796-1874)--the average man and indices of obesity. *Nephrology, Dialysis, Transplantation, 23*(1), 47-51.
El-Hajj Fuleihan, G. (2009). Vitamin D deficiency in the Middle East and its health consequences for children and adults. *Clinical Review in Bone and Mineral Metabolism, 7*(1), 77-93.
Engelsen, O. (2010). The relationship between ultraviolet radiation exposure and vitamin D status. *Nutrients, 2*(5), 482-495.
Erkkola, M., Kaila, M., Nwaru, B. I., Kronberg-Kippil, C., Ahonen, S., Nevalainen, J., et al. (2009). Maternal vitamin D intake during pregnancy is inversely associated with asthma and allergic rhinitis in 5-year-old children. *Clinical & Experimental Allergy, 39*(6), 875-882.
Feskanich, D., Willett, W. C., & Colditz, G. A. (2003). Calcium, vitamin D, milk consumption, and hip fractures: a prospective study among postmenopausal women. *American Journal of Clinical Nutrition, 77*(2), 504-511.
Fronczak, C. M., Barón, A. E., Chase, H. P., Ross, C., Brady, H. L., Hoffman, M., et al. (2003). In utero dietary exposures and risk of islet autoimmunity in children. *Diabetes Care, 26*(12), 3237-3242.
Garland, C. F., Gorham, E. D., Mohr, S. B., & Garland, F. C. (2009). Vitamin D for cancer prevention: global perspective. *Ann Epidemiol., 19*(7), 468-483.
Giam, Y.-C., Williams, Mary L., LeBoit, Philip E., Orlow, Seth J., Eichenfield, Lawrence F., & Frieden, Ilona J. (1999). Neonatal erosions and ulcerations in giant congenital melanocytic nevi. *Pediatric Dermatology, 16*(5), 354-358.
Ginde, A. A., Sullivan, A. F., Mansbach, J. M., & Camargo, C. A., Jr. (2010). Vitamin D insufficiency in pregnant and nonpregnant women of childbearing age in the United States. *American Journal of Obstetrics and Gynecology*(1097-6868 (Electronic)), 1.e1-1.e8.
Godar, D. E., Pope, S. J., Grant, W. B., & Holick, M. F. (2011). Solar UV doses of adult Americans and vitamin D(3) production. *Dermato-endocrinology, 3*(4), 243-250.
Grant, W. B., & Soles, C. M. (2009). Epidemiologic evidence supporting the role of maternal vitamin D deficiency as a risk factor for the development of infantile autism. *Dermatoendocrinol, 1*(4), 223-228.
Green, A., Williams, G., Nèale, R., Hart, V., Leslie, D., Parsons, P., et al. (1999). Daily sunscreen application and betacarotene supplementation in prevention of basal-cell and squamous-cell carcinomas of the skin: a randomised controlled trial. *The Lancet, 354*(9180), 723-729.
Grover, S. R., & Morley, R. (2001). Vitamin D deficiency in veiled or dark-skinned pregnant women. *Medical Journal of Australia, 175*(5), 251-252.
Grundmann, M., & von Versen-Höynck, F. (2011). Vitamin D - roles in women's reproductive health? *Reproductive Biology and Endocrinology, 9*, 146-157.
Halicioglu, O., Aksit, S., Koc, F., Akman, S. A., Albudak, E., Yaprak, I., et al. (2012). Vitamin D deficiency in pregnant women and their neonates in spring time in western Turkey. *Paediatric and Perinatal Epidemiology, 26*(1), 53-60.

Haugen, M., Brantsaeter, A. L., Alexander, J., & Meltzer, H. M. (2008). Dietary supplements contribute substantially to the total nutrient intake in pregnant Norwegian women. *Annals of Nutrition and Metabolism, 52*(4), 272-280.
Haugen, M., Brantsaeter, A. L., Trogstad, L., Alexander, J., Roth, C., Magnus, P., et al. (2009). Vitamin D supplementation and reduced risk of preeclampsia in nulliparous women. *Epidemiology, 20*(5), 720-726.
Heaney, R. P. (2000). Vitamin D: how much do we need, and how much is too much? *Osteoporos Int., 11*(7), 553-555.
Heaney, R. P., Davies, K. M., Chen, T. C., Holick, M. F., & Barger-Lux, M. J. (2003). Human serum 25-hydroxycholecalciferol response to extended oral dosing with cholecalciferol. *The American Journal of Clinical Nutrition, 77*(1), 204-210.
Heaney, R. P., Dowell, M. S., Hale, C. A., & Bendich, A. (2003). Calcium absorption varies within the reference range for serum 25-hydroxyvitamin D. *J Am Coll Nutr, 22*(2), 142-146.
Henderson, L., Irving, K., Gregory, J., Bates, C. J., Prentice, A., Perks, J., et al. (2003). The National Diet and Nutrition Survey: adults aged 19 to 64 years-vitamin and mineral intake and urinary analysis. http://www.food.gov.uk/multimedia/pdfs/ndnsfour.pdf Retrieved 20 August, 2012
Hien, V. T., Lam, N. T., Skeaff, C. M., Todd, J., McLean, J. M., & Green, T. J. (2011). Vitamin D status of pregnant and non-pregnant women of reproductive age living in Hanoi City and the Hai Duong province of Vietnam. *Maternal and Child Nutrition*, doi: 10.1111/j.1740-8709.2011.00327.x. [Epub ahead of print].
Holick, M. F. (1995). Environmental factors that influence the cutaneous production of vitamin D. *Am J Clin Nutr, 61*(3), 638S-645.
Holick, M. F. (2003). Vitamin D: A millenium perspective. *Journal of Cellular Biochemistry, 88*(2), 296-307.
Holick, M. F. (2004). Sunlight and vitamin D for bone health and prevention of autoimmune diseases, cancers, and cardiovascular disease. *Am J Clin Nutr, 80*(6), 1678S-1688.
Holick, M. F. (2005). The influence of vitamin D on bone health across the life cycle. *J Nutr, 135*(11), 2726S-2727S.
Holick, M. F. (2005). The vitamin D epidemic and its health consequences. *J. Nutr., 135*(11), 2739S-2748.
Holick, M. F. (2006). High prevalence of vitamin D inadequacy and implications for health. *Mayo Clinic Proceedings, 81*(3), 353-373.
Holick, M. F. (2007). Vitamin D deficiency. *N Engl J Med, 357*(3), 266-281.
Holick, M. F. (2008). The vitamin D deficiency pandemic and consequences for nonskeletal health: mechanisms of action. *Molecular Aspects of Medicine, 29*(6), 361-368.
Holick, M. F. (2011). Vitamin D: A D-lightful solution for health. *Journal of Investigative Medicine, 59*(6), 872-880.
Holick, M. F., & Chen, T. C. (2008). Vitamin D deficiency: a worldwide problem with health consequences. *Am J Clin Nutr, 87*(4), 1080S-1086.
Hollis, B. W. (2005). Circulating 25-hydroxyvitamin D levels indicative of vitamin D sufficiency: implications for establishing a new effective dietary intake recommendation for vitamin D. *J. Nutr., 135*(2), 317-322.

Hollis, B. W. (2007). Vitamin D requirement during pregnancy and lactation. *Journal of Bone and Mineral Research, 22*(s2), V39-V44.
Hollis, B. W., Johnson, D., Hulsey, T. C., Ebeling, M., & Wagner, C. L. (2011). Vitamin D supplementation during pregnancy: Double blind, randomized clinical trial of safety and effectiveness. *Journal of Bone and Mineral Research, 26*(10), 2341-2357.
Hollis, B. W., & Wagner, C. L. (2012). Vitamin D and pregnancy: skeletal effects, nonskeletal effects, and birth outcomes. *Calcified Tissue International*.
Holmes, V. A., Barnes, M. S., Alexander, H. D., McFaul, P., & Wallace, J. M. (2009). Vitamin D deficiency and insufficiency in pregnant women: a longitudinal study. *Br J Nutr, 102*(6), 876-881.
Hossein-Nezhad, A., & Holick, M. F. (2012). Optimize dietary intake of vitamin D: an epigenetic perspective. *Current Opinion in Clinical Nutrition and Metabolic Care, 15*(6), 567-579.
Imdad, A., & Bhutta, Z. A. (2012). Routine iron/folate supplementation during pregnancy: effect on maternal anaemia and birth outcomes. *Paediatric and Perinatal Epidemiology, 26*(s1), 168-177.
Innes, A. M., Seshia, M. M., Prasad, C., Al Saif, S., Friesen, F. R., Chudley, A. E., et al. (2002). Congenital rickets caused by maternal vitamin D deficiency. *Paediatr Child Health, 7*(7), 455-458.
Janssen, H. C. J. P., Samson, M. M., & Verhaar, H. J. J. (2002). Vitamin D deficiency, muscle function, and falls in elderly people. *Am J Clin Nutr, 75*(4), 611-615.
Jasinghe, V. J., Perera, C. O., & Barlow, P. J. (2005). Bioavailability of vitamin D2 from irradiated mushrooms: an in vivo study. *Br J Nutr., 93*(6), 951-955.
Javaid, M. K., Crozier, S. R., Harvey, N. C., Gale, C. R., Dennison, E. M., Boucher, B. J., et al. (2006). Maternal vitamin D status during pregnancy and childhood bone mass at age 9 years: a longitudinal study. *Lancet, 367*(9504), 36-43.
Javaid, M. K., Crozier, S. R., Harvey, N. C., Taylor, P., Inskip, H. M., Godfrey, K. M., et al. (2005). Maternal and seasonal predictors of change in calcaneal quantitative ultrasound during pregnancy. *Journal of Clinical Endocrinology and Metabolism, 90*(9), 5182-5187.
Jayaratne, N., Russell, A., & van der Pols, J. C. (2012). Sun protection and vitamin D status in an Australian subtropical community. *Preventive Medicine, 55*(2), 146-150.
Jenab, M., Bueno-de-Mesquita, H. B., Ferrari, P., van Duijnhoven, F. J., Norat, T., Pischon, T., et al. (2010). Association between pre-diagnostic circulating vitamin D concentration and risk of colorectal cancer in European populations:a nested case-control study. *BMJ, 340*, b5500.
Jensen, C. B., Petersen, S. B., Granstrom, C., Maslova, E., Molgaard, C., & Olsen, S. F. (2012). Sources and determinants of vitamin D intake in Danish pregnant women. *Nutrients, 4*(4), 259-272.
John, E. M., Schwartz, G. G., Koo, J., Wang, W., & Ingles, S. A. (2007). Sun exposure, vitamin D receptor gene polymorphisms, and breast cancer risk in a multiethnic population. *American Journal of Epidemiology, 166*(12), 1409-1419.
Jorde, R., & Bønna, K. H. (2000). Calcium from dairy products, vitamin D intake, and blood pressure: the Tromsø study. *The American Journal of Clinical Nutrition, 71*(6), 1530-1535.

Kabi, F., Mkinsi, O., & Zrigui, J. (2006). Pregnancy-associated osteoporosis. A new case. *Revue de Medecine Interne, 27*(7), 558-560.
Karatekin, G., Kaya, A., Salihoglu, O., Balci, H., & Nuhoglu, A. (2007). Association of subclinical vitamin D deficiency in newborns with acute lower respiratory infection and their mothers. *Eur J Clin Nutr, 63*(4), 473-477.
Kazemi, A., Sharifi, F., Jafari, N., & Mousavinasab, N. (2009). High prevalence of vitamin D deficiency among pregnant women and their newborns in an Iranian population. *J Womens Health (Larchmt), 18*(6), 835-839.
Kessenich, C. R. (2010). Vitamin D deficiency and leg pain in the elderly. *Nurse Practitioner, 35*(3), 12-13.
Kim, B. H., Glanz, K., & Nehl, E. J. (2012). Vitamin D beliefs and associations with sunburns, sun exposure, and sun protection. *International Journal of Environmental Research and Public Health, 9*(7), 2386-2395.
Kimlin, M., Harrison, S., Nowak, M., Moore, M., Brodie, A., & Lang, C. (2007). Does a high UV environment ensure adequate vitamin D status? *J Photochem Photobiol B, 89*(2-3), 139-147.
Kimlin, M. G., Parisi, A. V., & Wong, J. C. (1998). Quantification of personal solar UV exposure of outdoor workers, indoor workers and adolescents at two locations in Southeast Queensland. *Photodermatology, Photoimmunology and Photomedicine, 14*(1), 7-11.
Ko, P., Burkert, R., McGrath, J., & Eyles, D. (2004). Maternal vitamin D3 deprivation and the regulation of apoptosis and cell cycle during rat brain development. *Developmental Brain Research, 153*(1), 61-68.
Kovacs, C. S. (2008). Vitamin D in pregnancy and lactation: maternal, fetal, and neonatal outcomes from human and animal studies. *Am J Clin Nutr, 88*(2), 520S-528.
Kung, A. W., & Lee, K. K. (2006). Knowledge of vitamin D and perceptions and attitudes toward sunlight among Chinese middle-aged and elderly women: a population survey in Hong Kong. *BMC Public Health, 6*, 226.
Lagunova, Z., Porojnicu, A. C., Lindberg, F., Hexeberg, S., & Moan, J. (2009). The dependency of vitamin D status on body mass index, gender, age and season. *Anticancer Res, 29*(9), 3713-3720.
Lakhdar, H., Zouhair, K., Khadir, K., Essari, A., Richard, A., Seite, S., et al. (2007). Evaluation of the effectiveness of a broad-spectrum sunscreen in the prevention of chloasma in pregnant women. *Journal of the European Academy of Dermatology and Venereology, 21*(6), 738-742.
LaMarca, B. D., Gilbert, J., & Granger, J. P. (2008). Recent progress toward the understanding of the pathophysiology of hypertension during preeclampsia. *Hypertension, 51*(4), 982-988.
Lamberg-Allardt, C., Karkkainen, M., Seppanen, R., & Bistrom, H. (1993). Low serum 25-hydroxyvitamin D concentrations and secondary hyperparathyroidism in middle-aged white strict vegetarians. *Am J Clin Nutr, 58*(5), 684-689.
Lapillonne, A. (2009). Vitamin D deficiency during pregnancy may impair maternal and fetal outcomes. *Med Hypotheses*.
Leffelaar, E. R., Vrijkotte, T. G. M., & van Eijsden, M. (2010). Maternal early pregnancy vitamin D status in relation to fetal and neonatal growth: results of the multi-ethnic Amsterdam Born Children and their Development cohort. *British Journal of Nutrition, 104*(01), 108-117.

Lehmann, B., & Meurer, M. (2010). Vitamin D metabolism. *Dermatologic Therapy, 23*(1), 2-12.

Li, W., Green, T. J., Innis, S. M., Barr, S. I., Whiting, S. J., Shand, A., et al. (2011). Suboptimal vitamin D levels in pregnant women despite supplement use. *Canadian Journal of Public Health, 102*(4), 308-312.

Lim, S. K., Kung, A. W. C., Sompongse, S., Soontrapa, S., & Tsai, K. S. (2008). Vitamin D inadequacy in postmenopausal women in Eastern Asia. *Current Medical Research and Opinion, 24*(1), 99-106.

Linos, E., Keiser, E., Kanzler, M., Sainani, K. L., Lee, W., Vittinghoff, E., et al. (2012). Sun protective behaviors and vitamin D levels in the US population: NHANES 2003-2006. *Cancer Causes and Control, 23*(1), 133-140.

Lo, C. W., Paris, P. W., Clemens, T. L., Nolan, J., & Holick, M. F. (1985). Vitamin D absorption in healthy subjects and in patients with intestinal malabsorption syndromes. *Am J Clin Nutr, 42*(4), 644-649.

Lucas, R. M., Ponsonby, A. L., Pasco, J. A., & Morley, R. (2008). Future health implications of prenatal and early-life vitamin D status. *Nutr Rev, 66*(12), 710-720.

Maghbooli, Z., Hossein-Nezhad, A., Karimi, F., Shafaei, A. R., & Larijani, B. (2008). Correlation between vitamin D3 deficiency and insulin resistance in pregnancy. *Diabetes Metab Res Rev, 24*(1), 27-32.

Mahon, P., Harvey, N., Crozier, S., Inskip, H., Robinson, S., Arden, N., et al. (2009). Low maternal vitamin D status and fetal bone development: cohort study. *Journal of Bone and Mineral Research, 25*(1), 11-13.

Makgoba, M., Nelson, S. M., Savvidou, M., Messow, C. M., Nicolaides, K., & Sattar, N. (2011). First-trimester circulating 25-hydroxyvitamin D levels and development of gestational diabetes mellitus. *Diabetes Care, 34*(5), 1091-1093.

Mallet, E., Gugi, B., Brunelle, P., Henocq, A., Basuyau, J. P., & Lemeur, H. (1986). Vitamin D supplementation in pregnancy: a controlled trial of two methods. *Obstetrics and Gynecology, 68*(3), 300-304.

Mannion, C. A., Gray-Donald, K., & Koski, K. G. (2006). Association of low intake of milk and vitamin D during pregnancy with decreased birth weight. *CMAJ, 174*(9), 1273-1277.

Marjamäki, L., Niinisto, S., Kenward, M. G., Uusitalo, L., Uusitalo, U., Ovaskainen, M. L., et al. (2010). Maternal intake of vitamin D during pregnancy and risk of advanced beta cell autoimmunity and type 1 diabetes in offspring. *Diabetologia., 53*(8), 1599-1607.

Marya, R. K., Rathee, S., Dua, V., & Sangwan, K. (1988). Effect of vitamin D supplementation during pregnancy on foetal growth. *Indian Journal of Medical Research, 88*, 488-492.

Mathews, F., Yudkin, P., Smith, R. F., & Neil, A. (2000). Nutrient intakes during pregnancy: the influence of smoking status and age. *Journal of Epidemiology and Community Health, 54*(1), 17-23.

Matsuoka, L. Y., Ide, L., Wortsman, J., Maclaughlin, J. A., & Holick, M. F. (1987). Sunscreens suppress cutaneous vitamin D3 synthesis. *J Clin Endocrinol Metab, 64*(6), 1165-1168.

Matsuoka, L. Y., Wortsman, J., Hanifan, N., & Holick, M. F. (1988). Chronic sunscreen use decreases circulating concentrations of 25-hydroxyvitamin D. A preliminary study. *Archives of Dermatology, 124*(12), 1802-1804.

Maxwell, J. D., Ang, L., Brooke, O. G., & Brown, I. R. F. (1981). Vitamin D supplements enhance weight gain and nutritional status in pregnant Asians. *BJOG: An International Journal of Obstetrics & Gynaecology, 88*(10), 987-991.

McCullough, M. L., Robertson, A. S., Rodriguez, C., Jacobs, E. J., Chao, A., Carolyn, J., et al. (2003). Calcium, vitamin D, dairy products, and risk of colorectal cancer in the Cancer Prevention Study II Nutrition Cohort (United States). *Cancer Causes and Control, 14*(1), 1-12.

McGrath, J. J., Eyles, D. W., Pedersen, C. B., Anderson, C., Ko, P., Burne, T. H., et al. (2010). Neonatal vitamin D status and risk of schizophrenia: a population-based case-control study. *Archives of General Psychiatry, 67*(9), 889-894.

McGrath, J. J., Keeping, D., Saha, S., Chant, D. C., Lieberman, D. E., & O'Callaghan, M. J. (2005). Seasonal fluctuations in birth weight and neonatal limb length; does prenatal vitamin D influence neonatal size and shape? *Early Hum Dev, 81*(7), 609-618.

Merewood, A., Mehta, S. D., Chen, T. C., Bauchner, H., & Holick, M. F. (2009). Association between vitamin D deficiency and primary cesarean section. *J Clin Endocrinol Metab, 94*(3), 940-945.

Merewood, A., Mehta, S. D., Grossman, X., Chen, T. C., Mathieu, J. S., Holick, M. F., et al. (2010). Widespread vitamin D deficiency in urban Massachusetts newborns and their mothers. *Pediatrics, 125*(4), 640-647.

Merlino, L. A., Curtis, J., Mikuls, T. R., Cerhan, J. R., Criswell, L. A., & Saag, K. G. (2004). Vitamin D intake is inversely associated with rheumatoid arthritis: results from the Iowa Women's Health Study. *Arthritis and Rheumatism, 50*(1), 72-77.

Miettinen, M. E., Reinert, L., Kinnunen, L., Harjutsalo, V., Koskela, P., Surcel, H. M., et al. (2012). Serum 25-hydroxyvitamin D level during early pregnancy and type 1 diabetes risk in the offspring. *Diabetologia, 55*(5), 1291-1294.

Millen, A. E., & Bodnar, L. M. (2008). Vitamin D assessment in population-based studies: a review of the issues. *Am J Clin Nutr, 87*(4), 1102S-1105.

Milman, N., Hvas, A. M., & Bergholt, T. (2011). Vitamin D status during normal pregnancy and postpartum. A longitudinal study in 141 Danish women. *Journal of Perinatal Medicine, 40*(1), 57-61.

Mirzaei, F., Michels, K. B., Munger, K., O'Reilly, E., Chitnis, T., Forman, M. R., et al. (2011). Gestational vitamin D and the risk of multiple sclerosis in offspring. *Annals of Neurology, 70*(1), 30-40.

Misra, M., Pacaud, D., Petryk, A., Collett-Solberg, P. F., Kappy, M., on behalf of the, D., et al. (2008). Vitamin D deficiency in children and its management: review of current knowledge and recommendations. *Pediatrics, 122*(2), 398-417.

Mithal, A., Wahl, D. A., Bonjour, J. P., Burckhardt, P., Dawson-Hughes, B., Eisman, J. A., et al. (2009). Global vitamin D status and determinants of hypovitaminosis D. *Osteoporos Int*.

Mitri, J., Muraru, M. D., & Pittas, A. G. (2011). Vitamin D and type 2 diabetes: a systematic review. *Eur J Clin Nutr, 65*(9), 1005-1015.

Moin, A., Jabery, Z., & Fallah, N. (2006). Prevalence and awareness of melasma during pregnancy. *International Journal of Dermatology, 45*(3), 285-288.

Montague, M., Borland, R., & Sinclair, C. (2001). Slip! Slop! Slap! and SunSmart, 1980-2000: Skin cancer control and 20 years of population-based campaigning. *Health Education and Behavior, 28*(3), 290-305.

Morales, E., Romieu, I., Guerra, S., Ballester, F. n., Rebagliato, M., Vioque, J. s., et al. (2012). Maternal vitamin D status in pregnancy and risk of lower respiratory tract infections, wheezing, and asthma in offspring. *Epidemiology, 23*(1), 64-71.

More, C., Bettembuk, P., Bhattoa, H. P., & Balogh, A. (2001). The effects of pregnancy and lactation on bone mineral density. *Osteoporosis International, 12*(9), 732-737.

Morley, R., Carlin, J. B., Pasco, J. A., & Wark, J. D. (2006). Maternal 25-hydroxyvitamin D and parathyroid hormone concentrations and offspring birth size. *J Clin Endocrinol Metab, 91*(3), 906-912.

Moyal, D. (2012). Need for a well-balanced sunscreen to protect human skin from both Ultraviolet A and Ultraviolet B damage. *Indian J Dermatol Venereol Leprol, 78 Suppl*, S24-30.

Mulligan, M. L., Felton, S. K., Riek, A. E., & Bernal-Mizrachi, C. (2009). Implications of vitamin D deficiency in pregnancy and lactation. *American Journal of Obstetrics and Gynecology, In Press, Corrected Proof*.

Munger, K. L., Zhang, S. M., O'Reilly, E., Hernan, M. A., Olek, M. J., Willett, W. C., et al. (2004). Vitamin D intake and incidence of multiple sclerosis. *Neurology, 62*(1), 60-65.

Nabulsi, M., Mahfoud, Z., Maalouf, J., Arabi, A., & Fuleihan, G. E. H. (2008). Impact of maternal veiling during pregnancy and socioeconomic status on offspring's musculoskeletal health. *Osteoporosis International, 19*(3), 295-302.

Narchi, H., Kochiyil, J., Zayed, R., Abdulrazzak, W., & Agarwal, M. (2011). Longitudinal study of vitamin D status in the 1st 6 months of life. *Annals of Tropical Paediatrics, 31*(3), 225-230.

Nicolaidou, P., Hatzistamatiou, Z., Papadopoulou, A., Kaleyias, J., Floropoulou, E., Lagona, E., et al. (2006). Low vitamin D status in mother-newborn pairs in Greece. *Calcif Tissue Int, 78*(6), 337-342.

Nikolaou, V., Stratigos, A. J., Antoniou, C., Sypsa, V., Avgerinou, G., Danopoulou, I., et al. (2009). Sun exposure behavior and protection practices in a Mediterranean population: a questionnaire-based study. *Photodermatology, Photoimmunology and Photomedicine, 25*(3), 132-137.

Norman, P. E., & Powell, J. T. (2005). Vitamin D, shedding light on the development of disease in peripheral arteries. *Arterioscler Thromb Vasc Biol, 25*(1), 39-46.

Nowak, M., Harrison, S. L., Buettner, P. G., Kimlin, M., Porter, D., Kennedy, L., et al. (2011). Vitamin D Status of Adults from Tropical Australia Determined Using Two Different Laboratory Assays: Implications for Public Health Messages. *Photochemistry and Photobiology, 87*(4), 935-943.

Nowson, C. A., & Margerison, C. (2002). Vitamin D intake and vitamin D status of Australians. *Med J Aust., 177*(3), 149-152.

Nowson, C. A., McGrath, J. J., Ebeling, P. R., Haikerwal, A., Daly, R. M., Sanders, K. M., et al. (2012). Vitamin D and health in adults in Australia and New Zealand: a position statement. *Medical Journal of Australia, 196*(11), 686-687.

Olausson, H., Laskey, M. A., Goldberg, G. R., & Prentice, A. (2009). Changes in bone mineral status and bone size during pregnancy and the influences of body weight and calcium intake. *Obstetrical and Gynecological Survey, 64*(2), 86-87

Orell–Kotikangas, H., Schwab, U., Österlund, P., Saarilahti, K., Mäkitie, O., & Mäkitie, A. A. (2012). High prevalence of vitamin D insufficiency in patients with head and neck cancer at diagnosis. *Head & Neck, Jan 27. doi: 10.1002/hed.21954. [Epub ahead of print]*.

Oudshoorn, C., Hartholt, K. A., van Leeuwen, J. P. T. M., Colin, E. M., van der Velde, N., & van der Cammen, T. J. M. (2012). Better knowledge on vitamin D and calcium in older people is associated with a higher serum vitamin D level and a higher daily dietary calcium intake. *Health Education Journal, 71*(4), 474-482.

Park, Y. K., Barton, C. N., & Calvo, M. S. (2001). Dietary contributions to serum 25(OH) vitamin D levels [25(OH)D] differ in black and white adults in the United States: Results from NHANES III. *J. Bone Miner.Res., 16*, F281.

Pasco, J., Henry, M., Nicholson, G., Sanders, K., & Kotowicz, M. (2001). Vitamin D status of women in the Geelong Osteoporosis Study: association with diet and casual exposure to sunlight. *Med J Aust., 175*(8), 401-405.

Paunier, L., Lacourt, G., Pilloud, P., Schlaeppi, P., & Sizonenko, P. C. (1978). 25-hydroxyvitamin D and calcium levels in maternal, cord and infant serum in relation to maternal vitamin D intake. *Helvetica Paediatrica Acta, 33*(2), 95-103.

Paxton, G. A., Teale, G. R., Nowson, C. A., Mason, R. S., McGrath, J. J., Thompson, M. J., et al. (2013). Vitamin D and health in pregnancy, infants, children and adolescents in Australia and New Zealand: a position statement. *The Medical Journal of Australia, 198*(3), 142-143.

Peechakara, S. V., & Pittas, A. G. (2008). Vitamin D as a potential modifier of diabetes risk. *Nat Clin Pract Endocrinol Metab, 4*(4), 182-183.

Perampalam, S., Ganda, K., Chow, K. A., Opie, N., Hickman, P. E., Shadbolt, B., et al. (2011). Vitamin D status and its predictive factors in pregnancy in 2 Australian populations. *Australian and New Zealand Journal of Obstetrics and Gynaecology, 51*(4), 353-359.

Perez-Ferre, N., Torrejon, M. J., Fuentes, M., Fernandez, M. D., Ramos, A., Bordiu, E., et al. (2012). Association of low serum 25-hydroxyvitamin D levels in pregnancy with glucose homeostasis and obstetric and newborn outcomes. *Endocrine Practice, 18*(5), 676-684.

Pilz, S., Marz, W., Wellnitz, B., Seelhorst, U., Fahrleitner-Pammer, A., Dimai, H. P., et al. (2008). Association of vitamin D deficiency with heart failure and sudden cardiac death in a large cross-sectional study of patients referred for coronary angiography. *J Clin Endocrinol Metab, 93*(10), 3927-3935.

Prentice, A., Goldberg, G. R., & Schoenmakers, I. (2008). Vitamin D across the lifecycle: physiology and biomarkers. *Am J Clin Nutr, 88*(2), 500S-506.

Prentice, A., Jarjou, L. M., Goldberg, G. R., Bennett, J., Cole, T. J., & Schoenmakers, I. (2009). Maternal plasma 25-hydroxyvitamin D concentration and birthweight, growth and bone mineral accretion of Gambian infants. *Acta Paediatr, 98*(8), 1360-1362.

Raiten, D. J., & Picciano, M. F. (2004). Vitamin D and health in the 21st century: bone and beyond. Executive summary. *Am J Clin Nutr, 80*(6), 1673S-1677.

Rifas-Shiman, S. L., Rich-Edwards, J. W., Willett, W. C., Kleinman, K. P., Oken, E., & Gillman, M. W. (2006). Changes in dietary intake from the first to the second trimester of pregnancy. *Paediatric and Perinatal Epidemiology, 20*(1), 35-42.

Ritchie, L. D., Fung, E. B., Halloran, B. P., Turnlund, J. R., Van Loan, M. D., Cann, C. E., et al. (1998). A longitudinal study of calcium homeostasis during human pregnancy and lactation and after resumption of menses. *Am J Clin Nutr, 67*(4), 693-701.

Robinson, J. K., Rigel, D. S., & Amonette, R. A. (1997). Trends in sun exposure knowledge, attitudes, and behaviors: 1986 to 1996. *Journal of the American Academy of Dermatology, 37*(2 Pt 1), 179-186.

Ross, A. C., Manson, J. E., Abrams, S. A., Aloia, J. F., Brannon, P. M., Clinton, S. K., et al. (2011). The 2011 report on Dietary Reference Intakes for calcium and vitamin D from the Institute of Medicine: What clinicians need to know. *Journal of Clinical Endocrinology & Metabolism, 96*(1), 53-58.

Rotko, T., Oglesby, L., Kunzli, N., & Jantunen, M. J. (2000). Population sampling in European air pollution exposure study, EXPOLIS: comparisons between the cities and representativeness of the samples. *Journal of Exposure Analysis and Environmental Epidemiology, 10*(4), 355-364.

Sabour, H., Hossein-Nezhad, A., Maghbooli, Z., Madani, F., Mir, E., & Larijani, B. (2006). Relationship between pregnancy outcomes and maternal vitamin D and calcium intake: A cross-sectional study. *Gynecological Endocrinology, 22*(10), 585-589.

Sachan, A., Gupta, R., Das, V., Agarwal, A., Awasthi, P. K., & Bhatia, V. (2005). High prevalence of vitamin D deficiency among pregnant women and their newborns in northern India. *Am J Clin Nutr, 81*(5), 1060-1064.

Salle, B. L., Delvin, E. E., Lapillonne, A., Bishop, N. J., & Glorieux, F. H. (2000). Perinatal metabolism of vitamin D. *Am J Clin Nutr, 71*(5), 1317S-1324.

Sayers, A., & Tobias, J. H. (2009). Estimated maternal ultraviolet B exposure levels in pregnancy influence skeletal development of the child. *J Clin Endocrinol Metab, 94*(3), 765-771.

Scholl, T. O., & Chen, X. (2009). Vitamin D intake during pregnancy: association with maternal characteristics and infant birth weight. *Early Hum Dev, 85*(4), 231-234.

Schwalfenberg, G. (2007). Not enough vitamin D: health consequences for Canadians. *Can Fam Physician, 53*(5), 841-854.

Seamans, K. M., & Cashman, K. D. (2009). Existing and potentially novel functional markers of vitamin D status: a systematic review. *Am J Clin Nutr, 89*(6), 1997S-2008.

Semba, R. D., Houston, D. K., Ferrucci, L., Cappola, A. R., Sun, K., Guralnik, J. M., et al. (2009). Low serum 25-hydroxyvitamin D concentrations are associated with greater all-cause mortality in older community-dwelling women. *Nutrition Research, 29*(8), 525-530.

Sharon, L., Robyn, M. L., Jane, H., & Anne-Louise, P. (2010). Vitamin D deficiency and pregnancy: From preconception to birth. *Molecular Nutrition & Food Research, 54*(5), 1-11.

Shibata, M., Suzuki, A., Sekiya, T., Sekiguchi, S., Asano, S., Udagawa, Y., et al. (2011). High prevalence of hypovitaminosis D in pregnant Japanese women with threatened premature delivery. *Journal of Bone and Mineral Metabolism, 29*(5), 615-620.

Sinclair, C. (2006). Risks and benefits of sun exposure: Implications for public health practice based on the Australian experience. *Progress in Biophysics and Molecular Biology, 92*(1), 173-178.

Sjogren, K., Hansson, E. E., & Stjernberg, L. (2011). Parenthood and factors that influence outdoor recreational physical activity from a gender perspective. *BMC Public Health, 11*, 93-102.
Smith, B. J., Ferguson, C., McKenzie, J., Bauman, A., & Vita, P. (2002). Impacts from repeated mass media campaigns to promote sun protection in Australia. *Health Promotion International, 17*(1), 51-60.
Specker, B. (2004). Vitamin D requirements during pregnancy. *Am J Clin Nutr, 80*(6), 1740S-1747.
Specker, B. L., Valanis, B., Hertzberg, V., Edwards, N., & Tsang, R. C. (1985). Sunshine exposure and serum 25-hydroxyvitamin D concentrations in exclusively breast-fed infants. *Journal of Pediatrics, 107*(3), 372-376.
Springbett, P., Buglass, S., & Young, A. R. (2010). Photoprotection and vitamin D status. *Journal of Photochemistry and Photobiology B: Biology, 101*(2), 160-168.
Stafford, R., Farrar, M. D., Kift, R., Durkin, M. T., Berry, J. L., Webb, A. R., et al. (2010). The impact of photosensitivity disorders on aspects of lifestyle. *British Journal of Dermatology, 163*(4), 817-822.
Stanton, W. R., Janda, M., Baade, P. D., & Anderson, P. (2004). Primary prevention of skin cancer: a review of sun protection in Australia and internationally. *Health Promotion International, 19*(3), 369-378.
Staples, M., Elwood, M., Burton, R., Williams, J., Marks, R., & Giles, G. (2006). Non-melanoma skin cancer in Australia: the 2002 national survey and trends since 1985. *Med J Aust., 184*(1), 6-10.
Stroud, M. L., Stilgoe, S., Stott, V. E., Alhabian, O., & Salman, K. (2008). Vitamin D: a review. *Australia Family Physician, 37*(12), 1002-1005.
Stumpf, U. C., Kurth, A. A., Windolf, J., & Fassbender, W. J. (2007). Pregnancy-associated osteoporosis: an underestimated and underdiagnosed severe disease. A review of two cases in short- and long-term follow-up. *Advances in Medical Sciences, 52*, 94-97.
Teaema, F. H., & Al Ansari, K. (2010). Nineteen cases of symptomatic neonatal hypocalcemia secondary to vitamin D deficiency: A 2-year study. *Journal of Tropical Pediatrics, 56*(2), 108-110.
Teale, G. R., & Cunningham, C. E. (2010). Vitamin D deficiency is common among pregnant women in rural Victoria. *Australian and New Zealand Journal of Obstetrics and Gynaecology, 50*(3), 259-261.
Thnc, O., Cetinkaya, S., Kizilgun, M., & Aycan, Z. (2011). Vitamin D status and insulin requirements in children and adolescent with type 1 diabetes. *J Pediatr Endocrinol Metab, 24*(11-12), 1037-1041.
Thorne-Lyman, A., & Fawzi, W. W. (2012). Vitamin D during pregnancy and maternal, neonatal and infant health outcomes: a systematic review and meta-analysis. *Paediatric and Perinatal Epidemiology, 26 Suppl 1*, 75-90.
Tsiaras, W. G., & Weinstock, M. A. (2011). Factors influencing vitamin D status. *Acta Derm Venereol, 91*(2), 115-124.
Tustin, K., Gross, J., & Hayne, H. (2004). Maternal exposure to first-trimester sunshine is associated with increased birth weight in human infants. *Developmental Psychobiology, 45*(4), 221-230.
van der Mei, I. A. F., Ponsonby, A.-L., Engelsen, O., Pasco, J. A., McGrath, J. J., Eyles, D. W., et al. (2007). The high prevalence of vitamin D insufficiency across Australian populations is only partly explained by season and latitude. *Environ Health Perspect. , 115*(8), 1132-1139.

Venning, G. (2005). Recent developments in vitamin D deficiency and muscle weakness among elderly people. *BMJ, 330*(7490), 524-526.
Vescini, F., Cozzi-Lepri, A., Borderi, M., Re, M. C., Maggiolo, F., De Luca, A., et al. (2011). Prevalence of hypovitaminosis D and factors associated with vitamin D deficiency and morbidity among HIV-infected patients enrolled in a large Italian cohort. *Journal of Acquired Immune Deficiency Syndromes, 58*(2), 163-172.
Viljakainen, H. T., Korhonen, T., Hytinantti, T., Laitinen, E. K., Andersson, S., Makitie, O., et al. (2011). Maternal vitamin D status affects bone growth in early childhood--a prospective cohort study. *Osteoporos Int, 22*(3), 883-891.
Viljakainen, H. T., Saarnio, E., Hytinantti, T., Miettinen, M., Surcel, H., Makitie, O., et al. (2010). Maternal vitamin D status determines bone variables in the newborn. *J Clin Endocrinol Metab*(1945-7197 (Electronic)).
Vu, L. H., van der Pols, J. C., Whiteman, D. C., Kimlin, M. G., & Neale, R. E. (2010). Knowledge and Attitudes about Vitamin D and Impact on Sun Protection Practices among Urban Office Workers in Brisbane, Australia. *Cancer Epidemiology Biomarkers & Prevention, 19*(7), 1784-1789.
Wagner, C. L., Taylor, S. N., Dawodu, A., Johnson, D. D., & Hollis, B. W. (2012). Vitamin D and its role during pregnancy in attaining optimal health of mother and fetus. *Nutrients, 4*(3), 208-230.
Waldie, K. E., Poulton, R., Kirk, I. J., & Silva, P. A. (2000). The effects of pre- and post-natal sunlight exposure on human growth: evidence from the Southern Hemisphere. *Early Human Development, 60*(1), 35-42.
Wang, J., Yang, F., Mao, M., Liu, D. H., Yang, H. M., & Yang, S. F. (2010). High prevalence of vitamin D and calcium deficiency among pregnant women and their newborns in Chengdu, China. *World J Pediatr, 6*(3), 265-267.
Wang, T. J., Pencina, M. J., Booth, S. L., Jacques, P. F., Ingelsson, E., Lanier, K., et al. (2008). Vitamin D deficiency and risk of cardiovascular disease. *Circulation, 117*(4), 503-511.
Ward, L. M., Gaboury, I., Ladhani, M., & Zlotkin, S. (2007). Vitamin D-deficiency rickets among children in Canada. *CMAJ, 177*(2), 161-166.
Wei, S. Q., Audibert, F., Hidiroglou, N., Sarafin, K., Julien, P., Wu, Y., et al. (2012). Longitudinal vitamin D status in pregnancy and the risk of pre-eclampsia. *BJOG: An International Journal of Obstetrics & Gynaecology, 119*(7), 832-839.
Weiler, H., Fitzpatrick-Wong, S., Veitch, R., Kovacs, H., Schellenberg, J., McCloy, U., et al. (2005). Vitamin D deficiency and whole-body and femur bone mass relative to weight in healthy newborns. *CMAJ, 172*(6), 757-761.
White, J. H. (2008). Vitamin D signaling, infectious diseases, and regulation of innate immunity. *Infect. Immun., 76*(9), 3837-3843.
Whitehouse, A. J. O., Holt, B. J., Serralha, M., Holt, P. G., Kusel, M. M. H., & Hart, P. H. (2011). Maternal serum vitamin D levels during pregnancy and offspring neurocognitive development. *Pediatrics, 129*(3), 485-493.
Widdowson, E. (1981). *Changes in body composition during growth*. London: William Heinemann Medical Books.
Wilkins, C. H., Sheline, Y. I., Roe, C. M., Birge, S. J., & Morris, J. C. (2006). Vitamin D deficiency is associated with low mood and worse cognitive performance in older adults. *American Journal of Geriatric Psych, 14*(12), 1032-1040.

Wolff, D., & Fitzhugh, E. C. (2011). The relationships between weather-related factors and daily outdoor physical activity counts on an urban greenway. *International Journal of Environmental Research and Public Health, 8*(2), 579-589.

Xu, Y., Hashizume, T., Shuhart, M. C., Davis, C. L., Nelson, W. L., Sakaki, T., et al. (2006). Intestinal and hepatic CYP3A4 catalyze hydroxylation of 1alpha,25-dihydroxyvitamin D(3): implications for drug-induced osteomalacia. *Mol Pharmacol, 69*(1), 56-65.

Yan, L., Prentice, A., Zhang, H., Wang, X., Stirling, D. M., & Golden, M. M. (2000). Vitamin D status and parathyroid hormone concentrations in Chinese women and men from north-east of the People's Republic of China. *Eur J Clin Nutr., 54*(1), 68-72.

Yu, C. K. H., Sykes, L., Sethi, M., Teoh, T. G., & Robinson, S. (2009). Vitamin D deficiency and supplementation during pregnancy. *Clinical Endocrinology, 70*(5), 685-690.

Zerwekh, J. E. (2008). Blood biomarkers of vitamin D status. *Am J Clin Nutr, 87*(4), 1087S-1091.

Zhang, C., Qiu, C., Hu, F. B., David, R. M., van Dam, R. M., Bralley, A., et al. (2008). Maternal plasma 25-hydroxyvitamin D concentrations and the risk for gestational diabetes mellitus. *PLoS One, 3*(11), e3753.

Ziegler, E. E., Hollis, B. W., Nelson, S. E., & Jeter, J. M. (2006). Vitamin D deficiency in breastfed infants in Iowa. *Pediatrics, 118*(2), 603-610.

Appendices

Appendix A

Survey One (the initial survey)

a university for the real world

Vitamin D and pregnancy: The knowledge, attitudes and behavior of Australian women

We are conducting this study to assess what pregnant women in Australia understand about the risks and benefits of sun exposure and vitamin D, for maternal health during pregnancy and for the health of new babies in the early postpartum period. There are 2 online surveys in this study. This is the first one. Participants will be sent a link to the second survey within the first two months of your baby's birth.

Page 1 of 46

Page 2 of 46

PARTICIPANT INFORMATION for QUT RESEARCH PROJECT

Vitamin D and pregnancy: The knowledge, attitudes and behaviour of Australian women

Research Team Contacts
Name: Prof. Michael Kimlin / Supervisor
Pone: 07 3138 5802
Email: m.kimlin@qut.edu.au

Name: Dr Yue Wu / PhD student
Pone: 07 3138 0330
Email: y14.wu@student.qut.edu.au

Description

This project is being conducted through the Queensland University of Technology, as part of a PhD project for Dr. Yue Wu. It will also form part of proposed longer term studies into sunlight, vitamin D and health with Professor Michael Kimlin.

Sun exposure in a sunny environment, such as here in Australia, has been thought to be sufficient for most people to make enough vitamin D. However, recent studies have shown that many Australians do not have adequate levels of vitamin D.

The health of expectant mothers is very important for the health of their babies. In other countries, many pregnant women have low levels of vitamin D and there are concerns about possible effects on the health of the baby. Little is known about this situation in Australia. The purpose of this project is to understand how much pregnant Australian women know about the good and bad effects of sun exposure, and how this affects their attitudes and behavior toward sun exposure and diet intake, both during pregnancy and in the early postpartum period.

We are currently seeking women who are pregnant (at least 3 months) and 18 years and older, to participate in a research study.

Participation

Your participation in this project is voluntary. If you do agree to participate, you can withdraw from participation at any time during the project without comment or penalty by contacting the researcher. You may elect to have all of your data removed from the database, or to allow the study to use any data that has already collected. Your decision to participate will in no way impact upon your current or future relationship with the Institute of Health and Biomedical Innovation (IHBI) or Queensland University of Technology (QUT). Your participation will involve the following steps:

First, log on to our website and complete the survey.

Second, 1-2 months after your baby is born, we will invite you to complete a further online survey to look at your attitudes and understanding about sun exposure and diet in regard to your new infant.

The first online survey is expected to take approximately 30-45 minutes to complete, and the follow-up survey is expected to take 15 minutes.

Expected Benefits

This study will contribute to new knowledge about sun exposure and vitamin D among pregnant women in Australia and will contribute to developing new sun exposure guidelines for Australians.

Risks

Your participation may involve minimal discomfort when reflecting on aspects of your medical and pregnancy history. If you feel any discomfort, you may stop completing the questionnaire.

Additionally, QUT provides free counselling for research participants of QUT projects, who may experience discomfort as a result of their participation in the research. Should you wish to access this service please contact the Clinic Receptionist of the QUT Psychology Clinic on 07 3138 0999. Please indicate to the receptionist that you are a research participant. Lifeline also offers free 24 hour telephone counselling and support on 13 11 14.

Confidentiality

All comments and responses will be treated confidentially.

Any identifying information (your full name, address etc.) will be stored separately from the information you provide. Access to this identifying information is restricted to a small number of senior members of this study team. We need to retain your identifying information so that the researcher can invite you to complete the second survey after your baby is born, and to enable the researchers to match the two parts of the results of this study. After that, all your surveys will be labeled with a unique barcode number and your identifying information will be removed.

All data will be kept at the Queensland University of Technology, in a locked storage cabinet. Data will also

All data will be kept at the Queensland University of Technology, in a locked storage cabinet. Data will also be stored in password-protected files on a computer within the Institute of Health and Biomedical Innovation (IHBI). The researchers will take every care to ensure that individually identifying material will be removed from the data as soon as it is possible, in order to preserve the privacy and confidentiality of the subjects. Your identity will not be disclosed in the reporting of the research.

Consent to Participate

Participation in this project is entirely voluntary. You will be asked to indicate your consent for participation by marking a check box that follows this Participant Information Sheet. You will not be able to access the survey without providing consent to participate. However, it is important to recognise that you are free to withdraw from the study at any time, by contacting the researcher.

Questions/Further information about the project

Please contact the research team members named above to have any questions answered or if you require further information about the project.

Concerns/Complaints regarding the conduct of the project

QUT is committed to researcher integrity and the ethical conduct of research projects. However, if you do have any concerns or complaints about the ethical conduct of the project you may contact the QUT Research Ethics Unit on 07 3138 5123 or email ethicscontact@qut.edu.au. The Research Ethics Unit is not connected with the research project and can facilitate a resolution to your concern in an impartial manner.

Thank you for helping with this research project. Please keep this sheet for your information. (You can print it out if you would like to!)

Page 5 of 46

1.
CONSENT FORM for QUT RESEARCH PROJECT

Vitamin D and pregnancy : The knowledge, attitudes and behaviour of Australian women

Research Team Contacts
Name: Prof. Michael Kimlin/ Supervisor
Pone: 07 3138 5802
Email: m.kimlin@qut.edu.au

Name: Dr. Yue Wu/ PhD student
Pone: 07 3138 0330
Email: y14.wu@student.qut.edu.au

Statement of consent

By ticking the box below, you are indicating that you:

have read and understood the Participant Information Sheet (above) regarding this projecthave had any questions answered to your satisfactionunderstand that if you have any additional questions you can contact the research teamunderstand that you are free to withdraw at any time, without comment or penaltyunderstand that you can contact the Research Ethics Unit on 07 3138 5123 or email ethicscontact@qut.edu.au if you have concerns about the ethical conduct of the projectagree to participate in the project

Please check all that apply.

☐ I ACCEPT

2. Date of giving consent (DD/MM/YYYY):

Please use the blank space to write your answers.

Part A

GENERAL HEALTH AND INFORMATION QUESTIONNAIRE

Page 6 of 46

3. Please enter your personal information here. This information is required in order for us to send you a reminder to complete a brief second survey after your baby is born.

All of the information that you provide will remain strictly confidential!

Please use the blank space to write your answers.

Name:

Address:

Postcode:

Phone or Email (Preferred contact method):

EDD (estimated date of delivery):

SECTION 1: GENERAL QUESTIONS ABOUT YOU

Firstly we would like to ask you some questions about your background:

4. What is your date of birth?

Please use the blank space to write your answers.

Date (DD/MM/YYYY):

5. Are you currently living in Australia?

Please pick one of the answers below and add your comments.

- ○ Yes
- ○ No

If you answer "No", please clarify the country you are currently living in::

Page 7 of 46

6. Were you born in Australia?

Please pick one of the answers below.

- O Yes
- O No

7. Where were you born?

Please use the blank space to write your answers.

Country of brith:

....

8. When did you come to live in Australia?

Please use the blank space to write your answers.

Year of arrival:

....

9. What state/territory do you live in? (Please tick one)

Please pick one of the answers below.

- O Queensland
- O New South Wales
- O Victoria
- O Tasmania
- O South Australia
- O Western Australia
- O ACT
- O Northern Territory

10. For how many years have you been living in this state/territory?

Please use the blank space to write your answers.

Years:

....

Page 8 of 46

11. What is your PARENTS' ETHNIC ORIGIN (that is the place where most of their ancestors came from) and the COUNTRY THEY WERE BORN IN.

Please fill in the answers in the table below (mark appropriate circles and squares and fill in the blank spaces).

	Country of Birth	Ethnic Origin (Pick the best description)	Other - Comments
Mother:	....	○ Australian Non-indigenous ○ Aboriginal and/or Torres Strait Islander ○ English ○ Irish ○ Vietnamese ○ Croatian ○ Chinese ○ Italian ○ Greek ○ Scottish ○ German ○ Lebanese ○ Dutch ○ Maltese ○ Polish ○ Filipino ○ Indian ○ Don't Know ○ Prefer not to answer ○ Other - Use Comment Box	....
Father:	....	○ Australian Non-indigenous ○ Aboriginal and/or Torres Strait Islander ○ English ○ Irish ○ Vietnamese ○ Croatian ○ Chinese ○ Italian ○ Greek ○ Scottish ○ German ○ Lebanese ○ Dutch ○ Maltese ○ Polish ○ Filipino ○ Indian ○ Don't Know ○ Prefer not to answer ○ Other - Use Comment Box	....

Page 9 of 46

12. What is the highest technical, professional or academic qualification that you have completed? (please tick one)

Please pick one of the answers below.

- O Did not complete primary school
- O Primary school
- O Some High School (Year 11 or under)
- O Year 12 Senior Certificate (or HSC)
- O Trade/ Apprenticeship
- O Certificate or Diploma
- O Bachelor's degree
- O Postgraduate degree

13. Which of the following best describes the occupation you had for the longest period? (please tick one)

Please pick one of the answers below or add your own.

- O Manager or administrator
- O Professional (e.g. engineer, doctor, teacher, nurse, police, technical officer)
- O Tradesperson (e.g. carpenter, electrician, plumber, mechanic, etc)
- O Clerk (e.g. typist, receptionist, data processor, etc)
- O Salesperson or personal service worker (e.g. sales rep., teller, insurance rep.,real estate rep.)
- O Plant or machine operator or driver (e.g. taxi driver, bus driver)
- O Farmer
- O Labourer or related worker (e.g. trade assistant, factory hand, agricultural labourer, construction, mining)
- O Member of defence force (army, navy, air force)

Other (please state)

....

14. Which of the following best decribes your current employment status? (Please tick one)

Please pick one of the answers below or add your own.

- ○ Unemployed
- ○ Home duties
- ○ Part-time work - employed/ self-employed
- ○ Full-time work - employed/ self-employed
- ○ Student
- ○ Sole parent pension
- ○ Disability pension
- ○ Retired

Other (please state)

....

15. Which of the following best describes your current, main occupation? (Please tick one)

Please pick one of the answers below.

- ○ Mainly indoors (e.g. office worker)
- ○ Half indoors and half outdoors (e.g. physical education teacher)
- ○ Mainly outdoors (e.g. gardener)

SECTION 2: SMOKING/ ALCOHOL CONSUMPTION
The following questions refer to smoking and alcohol consumption.

16. Were you ever a regular smoker of cigarettes or cigars or pipes?(A regular smoker is one who smoked daily, or at least 7 times per week, for at least 3 months.)

Please pick one of the answers below.

- ○ Yes
- ○ No

17. Are you currently a regular smoker of cigarettes or cigars or pipes?

Please pick one of the answers below.

- ○ Yes
- ○ No

18. Over the past month, on average, how many cigarettes and/or cigars and /or pipes did you smoke each day?

Please use the blank space to write your answers.

number per day:

....

19. Over the past month, which brand and type have you smoked most often?

Please use the blank space to write your answers.

Brand (e.g. Horizon/ Craven A / Winfield)

....

Type (e.g. Plain/ Super Mild/ Extra Mild (Blue))

....

20. Did they have a filter?

Please pick one of the answers below.

O Yes

O No

21. The next questions ask about your smoking history.

Please use the blank space to write your answers.

How old were you when you first became a regular smoker? Years of age:

....

If you are no longer a smoker, at what age did you stop? Years of age: (skip this question if you did not stop)

....

If you have stopped being a regular smoker in the past, and then started being one again (perhaps doing this several times) for how long in total have you stopped being a regular smoker? Years: (skip this question if you did not start and stop)

....

On average, during the years that you smoked, how many cigarettes, cigar or pipes did you smoke each day? Number per day:

....

22. About how many alcoholic drinks do you have each week? (one standard drink= a glass of wine, middy of beer or nip of spirits) Please put "0" if you don't drink, or have less than one standard drink each week.

Please use the blank space to write your answers.

number of standard alholic drinks each week

....

23. On how many days each week do you usually drink alcohol? Please put "0" if you don't drink, or have less than one standard drink each week.

Please use the blank space to write your answers.

Days each week

....

SECTION 3: GENERAL HEALTH INFORMATION

The following questions refer to your general health.

24. Overall, how would you rate your general health over the PAST MONTH? (please tick one)

Please pick one of the answers below.

- O Excellent
- O Very Good
- O Good
- O Fair
- O Poor
- O Very poor

25. Have you ever been dignosed with cancer?

Please pick one of the answers below.

- O Yes
- O No
- O Don't know

Page 13 of 46

26. What type of cancer were you dignosed with, and what was the month and year you were dignosed (or last dignosed) with this type of cancer? (please tick as many as apply)

Please fill in the answers in the table below (mark appropriate circles and squares and fill in the blank spaces).

	TYPE OF CANCER	MONTH AND YEAR OF DIGNOSIS (MM/YYYY)
Melanoma	☐	....
Other skin cancer (e.g. BCC or SCC: do not include sunspots)	☐	....
Colorectal cancer (bowel, rectum or colon)	☐	....
Breast cancer	☐	....
Lung cancer	☐	....
Cervical cancer	☐	....
Uterine or endometrial cancer	☐	....
Ovarian cancer	☐	....
Bladder or kidney cancer	☐	....
Stomach cancer	☐	....
Leukaemia	☐	....
Lymphoma (including Non- Hodgkin's Lymphoma)	☐	....
Cancer of an unknown primary site	☐	....
other	☐	....

27. If you chose "Other" in the previous question, please specify it below:

Please use the blank space to write your answers.

Cancer Type (Please specify)

....

SECTION 4: MEDICATION

The following questions ask about any medication you may take or have been prescribed. It will help you to have your medications with you so you can fill out the following medication chart.

Page 14 of 46

28. Has a doctor ever told you that you have any of these conditions? (Please tick as many as apply)

Please check all that apply.

- ☐ high blood pressure
- ☐ high cholesterol
- ☐ Osteomalacia
- ☐ Osteopaenia
- ☐ Rickets
- ☐ Osteoporosis
- ☐ None of the above conditions

29. Are you currently taking any medication prescribed by a doctor to treat this or these?

Please pick one of the answers below.

- O Yes
- O No

30. Please fill out the medication chart with your medication.

Please fill in the answers in the table below (mark appropriate circles and squares and fill in the blank spaces).

Matrix: part 1 of 2

	Name of medication	Strength of Medication on Packet (e.g. 5mg, 100IU, 20mg/ml)	Quantity taken each time (e.g. 2 tablets, 5ml)	Form of medication
Medication 1	....	....	....	O Tablet O Capsule O Patch O Liquid O Spray O Implant O Injection
Medication 2	....	....	....	O Tablet O Capsule O Patch O Liquid O Spray O Implant O Injection
Medication 3	....	....	....	O Tablet O Capsule O Patch O Liquid O Spray O Implant O Injection
Medication 4	....	....	....	O Tablet O Capsule O Patch O Liquid O Spray O Implant O Injection
Medication 5	....	....	....	O Tablet O Capsule O Patch O Liquid O Spray O Implant O Injection

Page 16 of 46

30. Please fill out the medication chart with your medication.

Please fill in the answers in the table below (mark appropriate circles and squares and fill in the blank spaces).

Matrix: part 2 of 2

	How often do you take it? (e.g. 3 times per week)
Medication 1	....
Medication 2	....
Medication 3	....
Medication 4	....
Medication 5	....

SECTION 5: PREGNANCY HEALTH INFORMATION

The following questions ask about your current pregnancy.

31. What is your estimated date of delivery?

Please use the blank space to write your answers.

Date (DD/MM/YYYY)

....

32. How many weeks pregnant are you now?

Please use the blank space to write your answers.

Weeks

....

33. What was your weight before pregnancy?

Please use the blank space to write your answers.

Weight (kg)

....

34. What is your weight now?

Please use the blank space to write your answers.

Weight (kg)

....

Page 17 of 46

35. What is your height?

Please use the blank space to write your answers.

Height (cm)

....

36. How many times have you been ever pregnant including the present?

Please use the blank space to write your answers.

Pregnant times:

....

37. How many times have you ever given birth?

Please use the blank space to write your answers.

Labour times:

....

SECTION 6: SUPPLEMENTS
The following questions ask about any supplements you may take or have been prescribed.

38. During the PAST MONTH, did you take any CALCIUM SUPPLEMENTS WITHOUT VITAMIN D?

Please pick one of the answers below.

- O Yes
- O No

39. During the PAST MONTH, did you take any CALCIUM SUPPLEMENTS WITH VITAMIN D?

Please pick one of the answers below.

- O Yes
- O No

40. During the PAST MONTH, did you take any COD LIVER OIL SUPPLEMENTS WITHOUT VITAMIN D?

Please pick one of the answers below.

- O Yes
- O No

Page 18 of 46

41. During the PAST MONTH, did you take any OTHER FISH OIL SUPPLEMENTS (such as krill oil or similar)?

Please pick one of the answers below.

- O Yes
- O No

42. During the PAST MONTH, did you take any VITAMIN D SUPPLEMENTS?

Please pick one of the answers below.

- O Yes
- O No

43. During the PAST MONTH, did you take any MULTIVITAMIN SUPPLEMENTS?

Please pick one of the answers below.

- O Yes
- O No

44. Please fill out the supplement chart. If you don't take any of the above supplements, please skip to the next question.

In the "Strength of Medication on Packet" column, please clarify what the medication is before giving the strength (e.g. Vitamin D3: 200IU, Fish oil:500mg, Calcium:59mg). If you took MULTIVITAMIN, please just clarify vitamin D, fish oil and calcium in the chart.

Please fill in the answers in the table below (mark appropriate circles and squares and fill in the blank spaces).

Matrix: part 1 of 2

	Name of medication	Strength of Medication on Packet (e.g. 5mg, 100IU, 20mg/ml)	Quantity taken each time (e.g. 2 tablets, 5ml)	Form of medication
Supplement 1	....	....	....	O Tablet O Capsule O Patch O Liquid O Spray O Implant O Injection
Supplement 2	....	....	....	O Tablet O Capsule O Patch O Liquid O Spray O Implant O Injection
Supplement 3	....	....	....	O Tablet O Capsule O Patch O Liquid O Spray O Implant O Injection
Supplement 4	....	....	....	O Tablet O Capsule O Patch O Liquid O Spray O Implant O Injection
Supplement 5	....	....	....	O Tablet O Capsule O Patch O Liquid O Spray O Implant O Injection

Page 20 of 46

44. Please fill out the supplement chart. If you don't take any of the above supplements, please skip to the next question.

In the "Strength of Medication on Packet" column, please clarify what the medication is before giving the strength (e.g. Vitamin D3: 200IU, Fish oil:500mg, Calcium:59mg). If you took MULTIVITAMIN, please just clarify vitamin D, fish oil and calcium in the chart.

Please fill in the answers in the table below (mark appropriate circles and squares and fill in the blank spaces).

Matrix: part 2 of 2

	How often do you take it? (e.g. 3 times per week)
Supplement 1	....
Supplement 2	....
Supplement 3	....
Supplement 4	....
Supplement 5	....

PART B SUN, SKIN,AND DIET QUESTIONNAIRE

SECTION 1: YOUR SKIN AND THE SUN

The following questions ask about your skin and how it reacts to the sun.

45. What is your natural skin colour?

Please pick one of the answers below.

- O Dark/black
- O Olive
- O Medium
- O Fair

Page 21 of 46

46. How does your skin react when you sit in the sun in your current area of residence, in the middle of the day for the first time in summer, without suncreen?

Please pick one of the answers below.

- ○ Never burn
- ○ Burn after more than 2 hours sun exposure
- ○ Burn after 1 - 2 hours
- ○ Burn after 1/2 - 1 hour
- ○ Burn within 1/2 hour

47. At the end of summer or after a two-week holiday in the sun, what kind of a tan would you have?

Please pick one of the answers below.

- ○ A dark tan
- ○ A medium tan
- ○ Light tan
- ○ Practically no tan

48. How does your skin react when you go out in the sun in your current area of residence, for one hour in the middle of the day, for the first time in summer, without suncreen?

Please pick one of the answers below.

- ○ Burn then peel
- ○ Burn then tan
- ○ Tan only

SECTION 2: TIME SPENT IN THE SUN

The following questions ask about your sun exposure in relation to your indoor and outdoor activities.

49. Have you worked a night shift at least once in the past month?

Please pick one of the answers below.

- ○ Yes
- ○ No

50. Please tell us approximately how many night shifts you have worked in the past month?

Please pick one of the answers below.

- ○ 1 night shift
- ○ 2 night shifts
- ○ 3 night shifts
- ○ 4 night shifts
- ○ 5-7 night shifts
- ○ 8-10 night shifts
- ○ 11-13 night shifts
- ○ 14-16 night shifts
- ○ 17-19 night shifts
- ○ 20 or more night shifts

Thinking about the PAST MONTH, we would like to know the TIME OF DAY as well as the USUAL LENGTH OF TIME that you spend OUTSIDE between sunrise and sunset on:

51. A typical MONDAY in the PAST MONTH

Please mark the corresponding circle - only one per line.

	Never	< 15 minutes	15-30 minutes	30-45 minutes	45-60 minutes
Morning 5-6am	O	O	O	O	O
Morning 6-7am	O	O	O	O	O
Morning 7-8am	O	O	O	O	O
Morning 8-9am	O	O	O	O	O
Morning 9-10am	O	O	O	O	O
Morning 10-11am	O	O	O	O	O
Morning 11-12am	O	O	O	O	O
Afternoon 12-1pm	O	O	O	O	O
Afternoon 1-2pm	O	O	O	O	O
Afternoon 2-3pm	O	O	O	O	O
Afternoon 3-4pm	O	O	O	O	O
Afternoon 4-5pm	O	O	O	O	O
Afternoon 5-6pm	O	O	O	O	O
Afternoon 6-7pm	O	O	O	O	O

52. A typical TUESDAY in the PAST MONTH

Please mark the corresponding circle - only one per line.

	Never	< 15 minutes	15-30 minutes	30-45 minutes	45-60 minutes
Morning 5-6am	○	○	○	○	○
Morning 6-7am	○	○	○	○	○
Morning 7-8am	○	○	○	○	○
Morning 8-9am	○	○	○	○	○
Morning 9-10am	○	○	○	○	○
Morning 10-11am	○	○	○	○	○
Morning 11-12am	○	○	○	○	○
Afternoon 12-1pm	○	○	○	○	○
Afternoon 1-2pm	○	○	○	○	○
Afternoon 2-3pm	○	○	○	○	○
Afternoon 3-4pm	○	○	○	○	○
Afternoon 4-5pm	○	○	○	○	○
Afternoon 5-6pm	○	○	○	○	○
Afternoon 6-7pm	○	○	○	○	○

53. A typical WEDNESDAY in the PAST MONTH

Please mark the corresponding circle - only one per line.

	Never	< 15 minutes	15-30 minutes	30-45 minutes	45-60 minutes
Morning 5-6am	O	O	O	O	O
Morning 6-7am	O	O	O	O	O
Morning 7-8am	O	O	O	O	O
Morning 8-9am	O	O	O	O	O
Morning 9-10am	O	O	O	O	O
Morning 10-11am	O	O	O	O	O
Morning 11-12am	O	O	O	O	O
Afternoon 12-1pm	O	O	O	O	O
Afternoon 1-2pm	O	O	O	O	O
Afternoon 2-3pm	O	O	O	O	O
Afternoon 3-4pm	O	O	O	O	O
Afternoon 4-5pm	O	O	O	O	O
Afternoon 5-6pm	O	O	O	O	O
Afternoon 6-7pm	O	O	O	O	O

Page 26 of 46

54. A typical THURSDAY in the PAST MONTH

Please mark the corresponding circle - only one per line.

	Never	< 15 minutes	15-30 minutes	30-45 minutes	45-60 minutes
Morning 5-6am	O	O	O	O	O
Morning 6-7am	O	O	O	O	O
Morning 7-8am	O	O	O	O	O
Morning 8-9am	O	O	O	O	O
Morning 9-10am	O	O	O	O	O
Morning 10-11am	O	O	O	O	O
Morning 11-12am	O	O	O	O	O
Afternoon 12-1pm	O	O	O	O	O
Afternoon 1-2pm	O	O	O	O	O
Afternoon 2-3pm	O	O	O	O	O
Afternoon 3-4pm	O	O	O	O	O
Afternoon 4-5pm	O	O	O	O	O
Afternoon 5-6pm	O	O	O	O	O
Afternoon 6-7pm	O	O	O	O	O

55. A typical FRIDAY in the PAST MONTH

Please mark the corresponding circle - only one per line.

	Never	< 15 minutes	15-30 minutes	30-45 minutes	45-60 minutes
Morning 5-6am	O	O	O	O	O
Morning 6-7am	O	O	O	O	O
Morning 7-8am	O	O	O	O	O
Morning 8-9am	O	O	O	O	O
Morning 9-10am	O	O	O	O	O
Morning 10-11am	O	O	O	O	O
Morning 11-12am	O	O	O	O	O
Afternoon 12-1pm	O	O	O	O	O
Afternoon 1-2pm	O	O	O	O	O
Afternoon 2-3pm	O	O	O	O	O
Afternoon 3-4pm	O	O	O	O	O
Afternoon 4-5pm	O	O	O	O	O
Afternoon 5-6pm	O	O	O	O	O
Afternoon 6-7pm	O	O	O	O	O

56. A typical SATURDAY in the PAST MONTH

Please mark the corresponding circle - only one per line.

	Never	< 15 minutes	15-30 minutes	30-45 minutes	45-60 minutes
Morning 5-6am	O	O	O	O	O
Morning 6-7am	O	O	O	O	O
Morning 7-8am	O	O	O	O	O
Morning 8-9am	O	O	O	O	O
Morning 9-10am	O	O	O	O	O
Morning 10-11am	O	O	O	O	O
Morning 11-12am	O	O	O	O	O
Afternoon 12-1pm	O	O	O	O	O
Afternoon 1-2pm	O	O	O	O	O
Afternoon 2-3pm	O	O	O	O	O
Afternoon 3-4pm	O	O	O	O	O
Afternoon 4-5pm	O	O	O	O	O
Afternoon 5-6pm	O	O	O	O	O
Afternoon 6-7pm	O	O	O	O	O

57. A typical SUNDAY in the PAST MONTH

Please mark the corresponding circle - only one per line.

	Never	< 15 minutes	15-30 minutes	30-45 minutes	45-60 minutes
Morning 5-6am	O	O	O	O	O
Morning 6-7am	O	O	O	O	O
Morning 7-8am	O	O	O	O	O
Morning 8-9am	O	O	O	O	O
Morning 9-10am	O	O	O	O	O
Morning 10-11am	O	O	O	O	O
Morning 11-12am	O	O	O	O	O
Afternoon 12-1pm	O	O	O	O	O
Afternoon 1-2pm	O	O	O	O	O
Afternoon 2-3pm	O	O	O	O	O
Afternoon 3-4pm	O	O	O	O	O
Afternoon 4-5pm	O	O	O	O	O
Afternoon 5-6pm	O	O	O	O	O
Afternoon 6-7pm	O	O	O	O	O

58. Is the PATTERN of sun exposure described adove FOR THE PAST MONTH, similar to your pattern of exposure over the previous 3 months?

Please pick one of the answers below.

- O Yes
- O No

59. Do you usually spend

Please pick one of the answers below.

- O MORE time in the sun
- O LESS time in the sun

60. Please tell me WHY your pattern of sun exposure has been DIFFERENT over the PAST MONTH? (Please tick as many as apply)

Please check all that apply and/or add your own variant.

- ☐ You were ill
- ☐ You were on holiday
- ☐ You changed the job

Other (please describe):

....

61. If you were ill, how many days of the month were you ill? (please skip to the next question if you didn't choose "ill" option)

Please use the blank space to write your answers.

Days:

....

62. If you were on holiday, how many days were you on holiday?
While on holiday, was your sun exposure more or less than usual?
(Please skip to the next question if you didn't choose "on holiday" option)

Please use the blank space to write your answers.

Days:

....

Compared with usual, more/less (please choose one) sun exposure:

....

63. If you changed your job, you are now working...(Please skip to the next question if you didn't choose "change job" option)

Please pick one of the answers below.

- ○ more outdoors
- ○ less outdoors
- ○ more shift work
- ○ less shift work

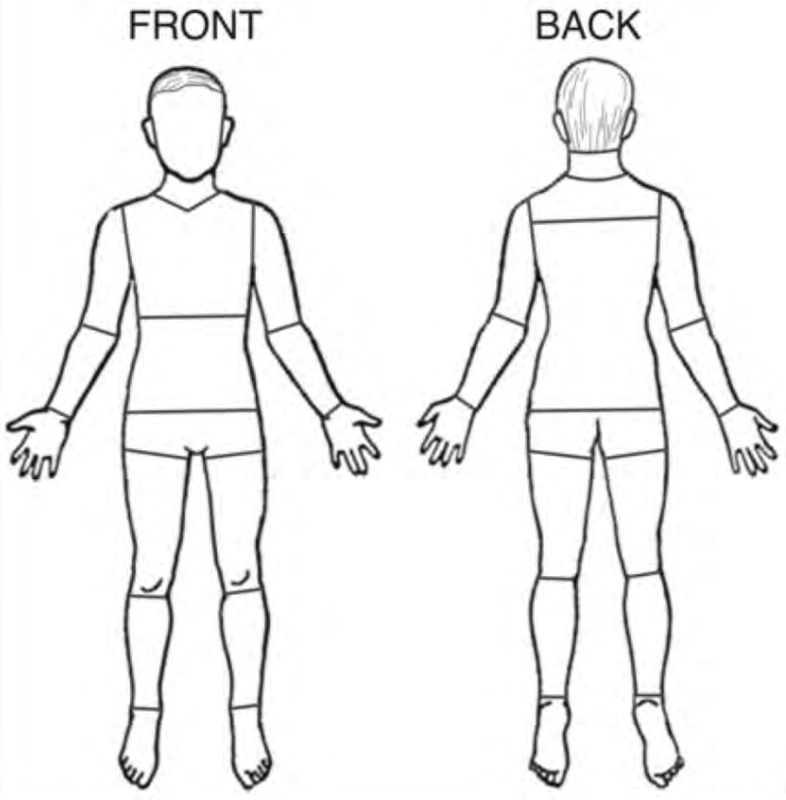
SECTION 3: SUN-PROTECTIVE BEHAVIOUR
The following questions ask about how you protect yourself from the sun.

68. On days that you have used sunscreen in the PAST MONTH, how often did you apply it?

Please use the blank space to write your answers.

Times per day

....



Page 33 of 46

69. Please look at the picture above and mark in the table WHERE you usually applied sunscreen when you used it over the PAST MONTH? Remember to include any products you mentioned before.

Please mark the corresponding circle - only one per line.

	Yes	No
Face	O	O
Neck	O	O
Trunk	O	O
Upper arms	O	O
Forearms	O	O
Hands	O	O
Thighs	O	O
Lower legs	O	O
Feet	O	O

SECTION 4: fOOD & DIETARY SUPPLEMENTS

In the following questions, we are interested in the amount of vitamin D that you received in your diet. Please tell us your food consumption in the PAST MONTH.

70. In the PAST MONTH, have you consumed vitamin D fortified milk?

Please pick one of the answers below and add your comments.

O Yes

O No

If "Yes", please write down the brand and type of milk (e.g. Pauls PhysiCAL, Pauls Trim):

....

71. In general, how many cups of vitamin D fortified milk would you have had each day in the past month? Remember to include any way in which you consumed vitamin D fortified milk (e.g. added to tea, coffee, cereal, porridge, or in cooking).

Please use the blank space to write your answers.

Cups of milk /day

....

Page 34 of 46

72. In the PAST MONTH, have you consumed vitamin D fortified yogurt?

Please pick one of the answers below and add your comments.

- O Yes
- O No

If "Yes", please write down the brand and type of yogurt (e.g. Yoplait Thick and Creamy):

....

73. On average, how many grams of vitamin D fortified yogurt would you have had each day in the past month?

Please use the blank space to write your answers.

quantity (g):

....

74. In the past month, how often did you eat any of the following fish?

Please fill in the answers in the table below (mark appropriate circles and squares and fill in the blank spaces).

	Frequency (Whole Number) (e.g. "3" serves)	Time period
Salmon (1 serve = 100g/ palm-sized piece)	....	O Daily O Weekly O Monthly O Never
Tuna (1 serve = 100g/ palm-sized piece)	....	O Daily O Weekly O Monthly O Never
Sardines (1 serve = 100g/ palm-sized piece)	....	O Daily O Weekly O Monthly O Never
Anchovies (1 serve = 100g/ palm-sized piece)	....	O Daily O Weekly O Monthly O Never
Mackerel (1 serve = 100g/ palm-sized piece)	....	O Daily O Weekly O Monthly O Never

75. In the past month, how often did you eat any of the following spreads/ eggs/ beef/ liver?

Please fill in the answers in the table below (mark appropriate circles and squares and fill in the blank spaces).

	Frequency (Whole Number) (e.g. "3" serves)	Time period
Margarine (1 tablespoon=20g)	....	O Daily O Weekly O Monthly O Never
Butter (1 tablespoon=20g)	....	O Daily O Weekly O Monthly O Never
Eggs (1 egg)	....	O Daily O Weekly O Monthly O Never
Beef (1 serve=100g / palm-sized piece)	....	O Daily O Weekly O Monthly O Never
Liver (1 serve=100g / palm-sized piece)	....	O Daily O Weekly O Monthly O Never

SECTION 5: PHYSICAL ACTIVITY

The following questions are about the amount of exercise that you do as part of your everyday life.

The questions will ask you about the time you spent being physically active in the LAST 7 DAYS.

Please answer each question even if you do not consider yourself to be an active person. Please think about the activities you do at work, as part of your house and yard work, to get from place to place, and in your spare time for recreation, exercise or sport. Driving does not count as physical activity.

Think about all the vigorous activities that you did in the LAST 7 DAYS.
Vigorous physical activities refer to activities that take hard physical effort and make you breathe much harder than normal. Think only about those physical activities that you did for at least 10 minutes at a time.

76. During the last 7 days on how many days did you do vigorous physical activities like heavy lifting, digging, aerobics, running, swimming, or fast bicycling?

Please pick one of the answers below and add your comments.

- ○ 1. Did vigorous physical activities and know the number of days during last week.
- ○ 2. Don't know/ Not sure.
- ○ 3. No vigorous physical activities.

If you choose the first option, please clarify the days per week:

....

77. How much time did you usually spend doing vigorous activities on one of those days? (e.g. 3 Hours and 10 Minutes)

Please fill in the answers in the table below (mark appropriate circles and squares and fill in the blank spaces).

	Hours	and Minutes
Per day inside:	....	....
Per day outside:	....	....

Think about all the moderate activities that you did in the LAST 7 DAYS.
Moderate activities refer to activities that take moderate physical effort and make you breathe somewhat harder than normal. Think only about those physical activities that you did for at least 10 minutes at a time.

78. During the last 7 days on how many days did you do moderate physical activities like carry light loads, bicycling at a regular pace, slow jogging, or doubles tennis? Do not include walking.

Please pick one of the answers below and add your comments.

- ○ 1. Did moderate physical activities and know the number of days during last week.
- ○ 2. Don't know/ Not sure.
- ○ 3. No moderate physical activities.

If you choose the first option, please clarify the days per week:

....

79. How much time did you usually spend doing moderate activities on one of those days? (e.g. 3 Hours plus 10 Minutes)

Please fill in the answers in the table below (mark appropriate circles and squares and fill in the blank spaces).

	Hours	and Minutes
per day inside:	....	....
per day outside:	....	....

Think about all the time you spend walking in the LAST 7 DAYS. This includes at work and at home, walking to travel from place to place, and walking that you might do solely for recreation, sport, exercise, or leisure.

80. During the last 7 days on how many days did you walk for at least 10 minutes at a time?

Please pick one of the answers below and add your comments.

- O 1. Had walking and know the number of days during last week.
- O 2. Don't know/ Not sure.
- O 3. No walking.

If you choose the first option, please clarify the days per week:

....

81. How much time did you usually spend walking on one of those days? (e.g. 3 Hours plus 10 Minutes)

Please fill in the answers in the table below (mark appropriate circles and squares and fill in the blank spaces).

	Hours	and Minutes
per day inside:	....	....
per day outside:	....	....

The last question in this section is about the time you spent sitting on weekdays during the LAST 7 DAYS. Include time spent at work, at home, while doing course work and during leisure time. This may include time spent sitting at a desk, visiting friends, or sitting or lying down to watch TV.

82. During the last 7 days, how much time did you spend sitting on a week day? (e.g. 3 Hours plus 10 Minutes)
If you don't know/ are not sure, please skip to the next question.

Please fill in the answers in the table below (mark appropriate circles and squares and fill in the blank spaces).

	Hours	and Minutes
per day inside:	....	....
per day outside:	....	....

83. Is this PATTERN of physical activity that you described above for the last 7 days, typical of your physical activity over the past month?

Please pick one of the answers below.

- O Yes
- O No

84. Do you usually spend...

Please pick one of the answers below and add your comments.

- More time being physically active
- Less time being physically active

please tell us the reason (e.g. ill, on holiday) :

PART C: SUN AND VITAMIN D KNOWLEDGE AND ATTITUDES QUESTIONNAIRE

SECTION 1: YOUR ATTITUDES TO SUN EXPOSURE AND TANNING
The following questions refer to your attitudes and behaviours to sun exposure, suntanning and use of solarium (tanning salons).

85. What would be your typical sun exposure behaviour if you are exposed to strong summer sunlight in a tropical location?

Please pick one of the answers below.

- Sun bake several hours each day
- Casual sun exposure only
- Use sun protection
- Avoid the sun at all times

86. Have you made any attempt to get a suntan this season?

Please pick one of the answers below.

- Yes
- No

87. Do you like to get a suntan?

Please pick one of the answers below.

- Yes
- No

Page 39 of 46

88. How deep a tan do you like to get?

Please pick one of the answers below.

- O Light
- O Moderate
- O Dark
- O Very dark

89. Have you EVER used a solarium (tanning salon)?

Please pick one of the answers below.

- O Yes
- O No

90. Have you been to a solarium (tanning salon) in the last 12 months?

Please pick one of the answers below.

- O Yes
- O No

91. During the last 12 months how many times did you attend?

Please pick one of the answers below.

- O Less than 5 times
- O 5 to 24 times
- O 24 to 50 times
- O More than 50 times

SECTION 2: YOUR KNOWLEDGE OF VITAMIN D

These next questions ask what you know about vitamin D.

Page 40 of 46

92. To the best of your knowledge, what are some of the health problems people may develop if they don't get enough vitamin D? You can write down up to 5 health problems below.

Please write your answer in the space below.

....

....

....

....

93. To the best of your knowledge, what symptoms and signs might suggest you are not getting enough vitamin D? You can write down up to 5 symptoms or signs below.

Please write your answer in the space below.

....

....

....

....

94. To the best of your knowledge, what things can people do to ensure they get enough vitamin D? You an write down up to 5 things people can do below.

Please write your answer in the space below.

....

....

....

....

95. Which of these strategies for ensuring adequate vitamin D levels do you think would be the main one?

Please write your answer in the space below.

....

....

....

....

96. Please tick the box to say whether you strongly agree, agree, disagree or strongly disagree or if you neither agree nor disagree with each statement.

Please mark the corresponding circle - only one per line.

	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree	Can't say
a. I need to spend more time in the sun during summer to get enough vitamin D to be healthy.	O	O	O	O	O	O
b. I worry about getting enough vitamin D	O	O	O	O	O	O
c. It is more important to stay out of the sun than it is to get enough vitamin D	O	O	O	O	O	O

97. Have you ever seen or heard any news reports about getting vitamin D from sunlight?

Please pick one of the answers below.

O Yes

O No

Page 42 of 46

98. In the last 12 months, have any of the following suggested to you that you are not getting enough vitamin D

Please mark the corresponding circle - only one per line.

	Yes	No	Can't say
GP/ Family doctor	O	O	O
Specialist doctor	O	O	O
Family/ friends	O	O	O
News media	O	O	O
TV show	O	O	O
Internet	O	O	O
Other	O	O	O

99. Last summer did you make any changes to the way you protect yourself from the sun so you could get enough vitamin D?
Did you...

Please mark the corresponding circle - only one per line.

	Yes	No	Can't say
a. Try to wear a hat less often?	O	O	O
b. Try to use sunscreen less often?	O	O	O
c. Try to wear shorts or short sleeved clothing more often?	O	O	O
d. Try to spend more time out in the sun?	O	O	O
e. Make any other changes to the way you protect yourself from the sun?	O	O	O

SECTION 3: GENERAL HEALTH AND WELL BEING

The following questions ask about your general health and how you have been feeling in the PAST MONTH.

Please consider the last four weeks and answer the following questions by selecting the appropriate box.

Page 43 of 46

100. Have you been able to concentrate on what you're doing

Please pick one of the answers below.

- Better than usual
- Same as usual
- Less than usual
- Much less than usual

101. Have you lost much sleep over worry

Please pick one of the answers below.

- Not at all
- No more than usual
- Rather more than usual
- Much more than usual

102. Have you felt you were playing a useful part in things

Please pick one of the answers below.

- More so than usual
- Same as usual
- Less useful than usual
- Much less useful

103. Have you felt capable of making decisions about things

Please pick one of the answers below.

- More so than usual
- Same as usual
- Less than usual
- Much less than usual

104. Have you felt constantly under strain

Please pick one of the answers below.

- Not at all
- No more than usual
- Rather more than usual
- Much less than usual

Page 44 of 46

105. Have you felt you couldn't overcome your difficulties

Please pick one of the answers below.

- O Not at all
- O No more than usual
- O Rather more than usual
- O Much less than usual

106. Have you been able to enjoy your normal day-to-day activities

Please pick one of the answers below.

- O More so than usual
- O Same as usual
- O Less than usual
- O Much less than usual

107. Have you been able to face up to your problems

Please pick one of the answers below.

- O More so than usual
- O Same as usual
- O Less than usual
- O Much less than usual

108. Have you been feeling unhappy or depressed

Please pick one of the answers below.

- O Not at all
- O No more than usual
- O Rather more than usual
- O Much more than usual

109. Have you been losing confidence in yourself

Please pick one of the answers below.

- O Not at all
- O No more than usual
- O Rather more than usual
- O Much more than usual

Appendix B

Survey Two (the follow-up survey)

Vitamin D and pregnancy: The knowledge, attitudes and behaviour of Australian women

This is a follow-up survey as a part of the project "Vitamin D and pregnancy: the knowledge, attitudes and behaviour of Australian women". You have completed the first survey before your delivery, now please complete this second survey about your knowledge, attitudes and behaviour on sun exposure and vitamin D in regard to your newborn baby.

MATERNAL KNOWLEDGE, TTITUDES AND BEHAVIOUR FOR THEIR BABIES ON VITAMIN D QUESTIONNAIRE

1. First of all, please enter your personal information to help the researchers to match this survey with your first one. Thank you!

Please use the blank space to write your answers.

Name:

....

Email or Phone (The one you left last time):

....

Postcode:

....

Firstly we would like to ask you some questions about your baby's birth details. It will help you to have your baby's Personal Health Record book with you.

2. Information about you, the mother

Please use the blank space to write your answers.

Age at delivery:

....

Weight gain during pregnancy (kg):

....

Type of delivery (vaginal or caesarean):

....

3. Did you have Gestational Diabetes during pregnancy?

Please pick one of the answers below.

- O Yes
- O No

Page 1 of 6

4. Did you have Preeclampsia?

Please pick one of the answers below.

- O Yes
- O No

5. Details of your baby when he/she was born

Please use the blank space to write your answers.

Gestation (at how many weeks of pregnancy was the baby born):

....

Sex (Male or Female):

....

Birth weight (g):

....

Birth length (cm):

....

Head circumference (cm):

....

Apgar score at 1 minute:

....

Apgar score at 5 minutes:

....

Secondly we are interested in how much sun exposure your new baby gets and his/her vitamin D intake. There are no right or wrong answers!

6. How do you feed your baby?

Please pick one of the answers below and add your comments.

- O Breast milk only
- O Formula milk only
- O Both breast & formula

If you give formula, please give the formula's name:

....

Page 2 of 6

7. Which milk do you think contains more vitamin D, breast milk or formula milk?

Please pick one of the answers below.

- O Breast milk
- O Formula milk
- O Equal or similar
- O Unsure

8. Have you received any educational material about vitamin D during your pregnancy?

Please pick one of the answers below.

- O Yes
- O No
- O Can't remember

9. Did you have a test during pregnancy to measure your level of vitamin D?

Please pick one of the answers below.

- O Yes
- O No
- O Don't know / Decline to answer

10. How many weeks pregnant were you when this test was done?

Please use the blank space to write your answers.

Weeks of pregnancy:

11. What pathology company took the blood for the vitamin D test?

Please pick one of the answers below or add your own.

- ○ Sullivan Nicolaides Pathology (SNP)
- ○ Queensland Medical Laboratory (QML)
- ○ IQ
- ○ Symbion
- ○ Combined
- ○ Healthscope
- ○ My Lab

Other, please specify:

....

12. Do you know the result of your vitamin D level?

Please pick one of the answers below and add your comments.

- ○ Yes
- ○ No

If "Yes", please give us your result (unit should be included, e.g. 50nmol/L):

....

13. Is that OK for us to contact your doctor to find out your vitamin D level?

Please pick one of the answers below and add your comments.

- ○ Yes
- ○ No

If "Yes", please leave your doctor's name and phone number here:

....

14. Do you think your baby needs extra vitamin D in the form of drops or supplements?

Please pick one of the answers below.

- ○ Strongly Agree
- ○ Agree
- ○ Neither agree or disagree
- ○ Disagree
- ○ Strongly Disagree
- ○ Unsure

15. Do you think it is a good idea to intentionally sun your baby to get adequate vitamin D?

Please pick one of the answers below.

- O Strongly Agree
- O Agree
- O Neither agree or disagree
- O Disagree
- O Strongly Disagree
- O Unsure

16. How long would you like to sun your baby each day?

Please pick one of the answers below.

- O < 15 minutes
- O 15-30 minutes
- O 30-45 minutes
- O 45-60 minutes
- O > 60 minutes

17. What time would you prefer to bring your baby outside?

Please pick one of the answers below.

- O Before 10am
- O Between 10am - 2pm
- O After 2pm

18. Will you use protection for your baby when taking him/her outside?

Please pick one of the answers below.

- O Yes, I think so
- O No, I won't
- O It depends
- O Don't know yet

19. If so, what sort of sun protection will you use? Please tick as many as apply.

Please check all that apply and/or add your own variant.

- ☐ Clothing
- ☐ Sunscreen
- ☐ Shade
- ☐ Sunglasses

Other (Please specify):

20. If you use clothing, what kind of clothing will you choose? Please tick as many as apply. If you didn't choose "clothing" option above, please skip to the next question.

Please check all that apply and/or add your own variant.

- ☐ Hat
- ☐ Legs covering
- ☐ Trunk covering
- ☐ Arms covering

Other (Please specify):

21. If using sunscreen, which part of the body will you apply it to? Please tick as many as apply. If you didn't choose "sunscreen" option above, please skip this question.

Please check all that apply.

- ☐ Face
- ☐ Hands
- ☐ Arms
- ☐ Trunk
- ☐ Legs
- ☐ Feet

Page 6 of 6

Appendix C

Ethical Application Approval Letter

From: Research Ethics [ethicscontact@qut.edu.au]
Sent: Tuesday, 6 April 2010 10:43 AM
To: Michael Kimlin; YUE WU
Cc: Janette Lamb
Subject: Ethics Application Approval – 1000000151

Dear Prof Michael Kimlin

Project Title:

Vitamin D status among pregnant women and the outcome of their newborns in Brisbane

Approval Number: 1000000151

Clearance Until: 6/04/2013

Ethics Category: Human

This email is to advise that your application has been reviewed by the University Human Research Ethics Committee and confirmed as meeting the requirements of the National Statement on Ethical Conduct in Human Research.

Whilst the data collection of your project has received ethical clearance, the decision to commence and authority to commence may be dependent on factors beyond the remit of the ethics review process. For example, your research may need ethics clearance from other organisations or permissions from other organisations to access staff. Therefore the proposed data collection should not commence until you have satisfied these requirements.

If you require a formal approval certificate, please respond via reply email and one will be issued. This project has been awarded ethical clearance until 6/04/2013 and a progress report must be submitted for an active ethical clearance at least once every twelve months. Researchers who fail to submit an appropriate progress report may have their ethical clearance revoked and/or the ethical clearances of other projects suspended. When your project has been completed please advise us by email at your earliest convenience.

For variations, please complete and submit an online variation form:
http://www.research.qut.edu.au/ethics/forms/hum/var/variation.jsp

Please do not hesitate to contact the unit if you have any queries.

Regards
Research Ethics Unit | Office of Research
Level 4 | 88 Musk Avenue | Kelvin Grove
p: +61 7 3138 5123
e: ethicscontact@qut.edu.au
w: http://www.research.qut.edu.au/ethics/

Appendix D

Ethics Variation Approval Letter

From: Research Ethics [ethicscontact@qut.edu.au]
Sent: Wednesday, 15 December 2010 3:10 PM
To: YUE WU; Michael Kimlin
Cc: Janette Lamb
Subject: Ethics Variation – 1000000151

Dear Prof Michael Kimlin

Approval #: 1000000151

End Date: 4/6/2013

Project Title: Vitamin D and pregnancy: The knowledge, attitudes and behaviour of Australian women

This email is to advise that your variation has been considered by the Chair, University Human Research Ethics Committee. Approval has been provided for:

> Change in the title

> Change in the aims and objectives

> To recruit 384 pregnant (at least 3 months) women 18 years and older(the neonate group has been eliminated)

> For the pregnant women/mother group, the measurement of skin reflectance and, blood collection and analysis has also been eliminated

> Only a questionnaire study to pregnant participants Australia-wide, using web-based questionnaires (online surveys) instead of researcher administrated face-to face questionnaires.

> The inclusion of Prof David Kavanagh (QUT) and Dr Robyn Lucas (ANU) in the research team

> Revised start and finish dates: 10/12/2010 - 10/08/2012.

Please don't hesitate to contact us if you have any questions.

Regards

Janette Lamb on behalf of Chair UHREC
Research Ethics Unit | Office of Research
Level 4 | 88 Musk Avenue | Kelvin Grove
p: +61 7 3138 5123
e: ethicscontact@qut.edu.au
w: http://www.research.qut.edu.au/ethics/

Appendix E

Recruitment Advertisement in Newspapers

Mediaportal Report

20/06/2011

▶ **Pregnancy questions to answer**
Newcastle Herald, 20/06/11, General News, Page 55
By: None

Article Information	
Item ID:	00105902255
Circulation:	48,000
Number of words:	62

19/06/2011

▶ **Survey on vitamin D exposure**
Sunday Mail Brisbane, 19/06/11, General News, Page 45
By: Suellen Hinde

Article Information	
Item ID:	00105841144
Circulation:	498,673
Number of words:	106

18/06/2011

▶ **Mums-to-be studied for vitamin D**
Adelaide Advertiser, 18/06/11, General News, Page 38
By: None

Article Information	
Item ID:	00105750224
Circulation:	190,665
Number of words:	67

▶ **Pregnant women sought for research into Vitamin D**
Morning Bulletin, 18/06/11, General News, Page 57
By: AAP

Article Information	
Item ID:	00105759789
Circulation:	17,403
Number of words:	469

MEDIA MONITORS

▶ **Study seeks pregnant women**
Western Advocate, 18/06/11, General News, Page 14
By: None

Article Information	
Item ID:	00105790748
Circulation:	3,743
Number of words:	535

17/06/2011

▶ **FED:CheckUp medical column for June 17**
AAP Newswire, 17/06/11, National, Page 0
By: AAP

Article Information	
Item ID:	00105715160
Circulation:	0
Number of words:	690

MEDIA MONITORS

Newcastle Herald
20-Jun-2011
Page: 55
General News
Market: Newcastle NSW
Circulation: 48000
Type: Regional
Size: 24.82 sq.cms
MTWTFS-

Pregnancy questions to answer

AUSTRALIAN researchers are calling on expecting women for a study on the effect of vitamin D during pregnancy.

Queensland University of Technology paediatrician Yue Wu said a lack of the vitamin, which protects women from hypertension, could increase the risk of gestational diabetes.

Women all around Australia who are more than three months pregnant are being asked to complete an online survey at creuunandhealth.org.au/engage.

Ref: 105902255

MEDIA MONITORS

Sunday Mail Brisbane
19-Jun-2011
Page: 45
General News
Market: Brisbane
Circulation: 498673
Type: Capital City Daily
Size: 108.93 sq.cms
-----S

HEALTHWATCH

WITH SUELLEN HINDE

Survey on vitamin D exposure

PREGNANT women are being sought to take part in a survey about vitamin D.

Deficiency in the vitamin is not uncommon during pregnancy, even among those living in countries with plenty of sunshine, its main source.

QUT PhD researcher Dr Yue Wu is asking pregnant women across Australia to participate in the online survey on sun exposure and vitamin D.

A previous Australian study had found that 15 per cent of pregnant women were vitamin D-deficient.

Dr Wu said sufficient vitamin D protected against hypertension and pre-eclampsia.

Women who are more than three months pregnant are needed for the survey at www.cresunandhealth.org.au/engage with—us

Ref: 105841144

MEDIA MONITORS

back

Adelaide Advertiser
18-Jun-2011
Page: 38
General News
Market: Adelaide
Circulation: 190665
Type: Capital City Daily
Size: 30.20 sq.cms
MTWTFS-

Mums-to-be studied for vitamin D

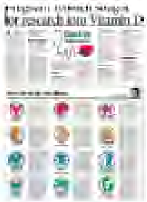
RESEARCHERS are calling on expectant women for a study into the effect of vitamin D during pregnancy.

Queensland University of Technology pediatrician Yue Wu said previous studies had found 15 per cent of mothers-to-be were vitamin D deficient.

Vitamin D protects pregnant women from hypertension and pre-eclampsia.

Dr Wu is seeking women who are more than three months pregnant to complete an online survey at http://www.cresunandhealth.org.au/engage

Ref: 105750224



Morning Bulletin
18-Jun-2011
Page: 57
General News
Market: Rockhampton QLD
Circulation: 17403
Type: Regional
Size: 355.67 sq.cms
MTWTFS-

Pregnant women sought for research into Vitamin D

AUSTRALIAN researchers are calling on expecting women for a study on the effect of vitamin D during pregnancy.

Queensland University of Technology paediatrician Yue Wu said previous studies had found 15% of mothers-to-be were vitamin D deficient.

Vitamin D protects pregnant women from hypertension and pre-eclampsia, Dr Wu said.

And a lack of the vitamin during pregnancy can increase the risk of gestational diabetes and lead to low birth weight.

"Evidence has accumulated that these babies can also run a higher risk of developing asthma and allergic outcomes as a consequence," Dr Wu said.

Dr Wu is seeking women all around Australia who are more than three months pregnant to complete an online survey at http://www.eresumandhealth.org.au/engage.

Docs struggling with Parkinson's

AUSTRALIAN GPs have significant gaps in their knowledge of the diagnosis and management of Parkinson's disease, a new study suggests.

Almost 170 doctors in NSW and the ACT were tested on their knowledge of symptoms of the disease and asked how to manage the condition.

The study, in the Journal of Clinical Neuroscience, found the average score was about 50% in assessment of both motor and non-motor symptoms of Parkinson's disease and both drug and non-drug management.

But when the doctors were reassessed after taking part in educational seminars conducted by Parkinson's Australia, their scores improved, with the average rising over 30%.

ADHD in pre-schoolers

PEDIATRICIANS are increasingly reluctant to prescribe stimulants for pre-schoolers with ADHD and seem to be turning to less-appropriate medications, new research suggests.

In an analysis of NSW records, Sydney University researchers found pre-schoolers had more severe ADHD compared to older children.

Figures showed the number of children under four prescribed stimulants for

Ref: 105759789

MEDIA MONITORS

Morning Bulletin
18-Jun-2011
Page: 57
General News
Market: Rockhampton QLD
Circulation: 17403
Type: Regional
Size: 355.67 sq.cms
MTWTFS-

ADHD dropped from 142 a year in 1997 to 35 a decade later.

About half had been prescribed psychotropic medications of known toxicity and unproven efficacy, medical journal 6minutes reported.

It's possible the process designed to protect children from inappropriate prescribing of stimulant medication could be indirectly promoting the prescription of medications that are considerably less suitable, they said.

Keeping it in the family

A BRITISH teacher is preparing to have her mother's womb transplanted into her in the hope she can have a baby, carrying it in the same womb that carried her.

Sara Ottoson, 25, was born without a uterus, London's Daily Telegraph reported.

Her mother, Eva Ottoson, 56, has agreed to take part in the groundbreaking procedure, becoming the first woman in the world to transplant her womb into her daughter.

If the procedure works Sara will have her own eggs fertilised using her boyfriend's sperm then implanted into the womb.

Flavoured milk out of favour

THE Los Angeles Unified School District has become the largest US school district to ban flavoured milk in an attempt to combat child obesity.

The school board voted this week to eliminate chocolate and strawberry-flavoured milk from schools as of July 1. - AAP

Ref: 105759789

Western Advocate
18-Jun-2011
Page: 14
General News
Market: Bathurst NSW
Circulation: 3743
Type: Regional
Size: 251.94 sq.cms
MTWTFS-

Study seeks pregnant women

AUSTRALIAN researchers are calling on pregnant women to take part in a study on the effect of vitamin D during pregnancy.

Queensland University of Technology pediatrician Yue Wu said previous studies had found 15 per cent of mothers-to-be were vitamin D deficient.

Vitamin D protects pregnant women from hypertension and pre-eclampsia, Dr Wu said.

And a lack of the vitamin during pregnancy can increase the risk of gestational diabetes and lead to low birth weight.

"Evidence has accumulated that these babies can also run a higher risk of developing asthma and allergic outcomes as a consequence," Dr Wu said.

■ ■ ■

AUSTRALIAN GPs have significant gaps in their knowledge of the diagnosis and management of Parkinsons disease, a new study suggests.

Almost 170 doctors in NSW and the ACT were tested on their knowledge of symptoms of the disease and asked how to manage the condition.

The study, in the Journal of Clinical Neuroscience, found the average score was about 50 per cent in assessment of both motor and non-motor symptoms of Parkinsons disease and both drug and non-drug drug management.

But when the doctors were reassessed after taking part in educational seminars conducted by Parkinsons Australia, their scores improved, with the average rising more than 20 per cent.

■ ■ ■

PAEDIATRICIANS are increasingly reluctant to prescribe stimulants for pre-schoolers with ADHD and seem to be turning to less appropriate medications, new research suggests.

In an analysis of NSW records, Sydney University researchers found pre-schoolers had more severe ADHD compared to older children.

Figures showed the number of children under four prescribed stimulants for ADHD dropped from 142 a year in 1997 to 35 a decade later.

About half had been prescribed psychotropic medications of known toxicity and unproven efficacy, medical journal 6minutes reported.

■ ■ ■

A BRITISH teacher is preparing to have her mother's womb transplanted into her in the hope she can have a baby, carrying it in the same womb that carried her.

Sara Ottoson, 25, was born without a uterus because of the condition Mayer-Rokitansky-Kuster-Hauser syndrome, London's *Daily Telegraph* reported.

Her mother, Eva Ottoson, 56, has agreed to take part in the groundbreaking procedure, becoming the first woman in the world to transplant her womb into her daughter.

The pair hope the complex transplant could take place next spring in Sweden, where doctors in Gothenburg have been assessing suitable patients for the surgery.

If the procedure works Sara, whose condition affects about one in 1500 women, will have her own eggs fertilised using her boyfriend's sperm then implanted into the womb.

Ref: 105790748

MEDIA MONITORS

Western Advocate
18-Jun-2011
Page: 14
General News
Market: Bathurst NSW
Circulation: 3743
Type: Regional
Size: 251.94 sq.cms
MTWTFS-

Study seeks pregnant women

AUSTRALIAN researchers are calling on pregnant women to take part in a study on the effect of vitamin D during pregnancy.

Queensland University of Technology pediatrician Yue Wu said previous studies had found 15 per cent of mothers-to-be were vitamin D deficient.

Vitamin D protects pregnant women from hypertension and pre-eclampsia, Dr Wu said.

And a lack of the vitamin during pregnancy can increase the risk of gestational diabetes and lead to low birth weight.

"Evidence has accumulated that these babies can also run a higher risk of developing asthma and allergic outcomes as a consequence," Dr Wu said.

■■■

AUSTRALIAN GPs have significant gaps in their knowledge of the diagnosis and management of Parkinsons disease, a new study suggests.

Almost 170 doctors in NSW and the ACT were tested on their knowledge of symptoms of the disease and asked how to manage the condition.

The study, in the Journal of Clinical Neuroscience, found the average score was about 50 per cent in assessment of both motor and non-motor symptoms of Parkinsons disease and both drug and non-drug drug management.

But when the doctors were reassessed after taking part in educational seminars conducted by Parkinsons Australia, their scores improved, with the average rising more than 20 per cent.

■■■

PAEDIATRICIANS are increasingly reluctant to prescribe stimulants for pre-schoolers with ADHD and seem to be turning to less appropriate medications, new research suggests.

In an analysis of NSW records, Sydney University researchers found pre-schoolers had more severe ADHD compared to older children.

Figures showed the number of children under four prescribed stimulants for ADHD dropped from 142 a year in 1997 to 35 a decade later.

About half had been prescribed psychotropic medications of known toxicity and unproven efficacy, medical journal 6minutes reported.

■■■

A BRITISH teacher is preparing to have her mother's womb transplanted into her in the hope she can have a baby, carrying it in the same womb that carried her.

Sara Ottoson, 25, was born without a uterus because of the condition Mayer-Rokitansky-Kuster-Hauser syndrome, London's *Daily Telegraph* reported.

Her mother, Eva Ottoson, 56, has agreed to take part in the groundbreaking procedure, becoming the first woman in the world to transplant her womb into her daughter.

The pair hope the complex transplant could take place next spring in Sweden, where doctors in Gothenburg have been assessing suitable patients for the surgery.

If the procedure works Sara, whose condition affects about one in 1500 women, will have her own eggs fertilised using her boyfriend's sperm then implanted into the womb.

Ref: 105790748

FED:CheckUp medical column for June 17

By Nicky Park

SYDNEY, June 17 AAP - A weekly round-up of news affecting your health.

SHOUT OUT FOR PREGNANT WOMEN

Australian researchers are calling on expecting women for a study on the effect of vitamin D during pregnancy.

Queensland University of Technology pediatrician Yue Wu, said previous studies had found 15 per cent of mothers-to-be were vitamin D deficient.

Vitamin D protects pregnant women from hypertension and pre-eclampsia, Dr Wu said.

And a lack of the vitamin during pregnancy can increase the risk of gestational diabetes and lead to low birth weight.

"Evidence has accumulated that these babies can also run a higher risk of developing asthma and allergic outcomes as a consequence," Dr Wu said.

It's unknown if women's vitamin D levels took a dive during pregnancy because of changes in sun exposure or whether it had to do with the growing foetus's requirements, or both.

Dr Wu is seeking women all around Australia who are more than three months pregnant to complete an online survey at http://www.cresunandhealth.org.au/engage

AAP

DOCS STRUGGLING WITH PARKINSONS

Australian GPs have significant gaps in their knowledge of the diagnosis and management of Parkinsons disease, a new study suggests.

Almost 170 doctors in NSW and the ACT were tested on their knowledge of symptoms of the disease and asked how to manage the condition.

The study, in the Journal of Clinical Neuroscience, found the average score was about 50 per cent in assessment of both motor and non-motor symptoms of Parkinsons disease and both drug and non-drug drug management.

But when the doctors were reassessed after taking part
in educational seminars conducted by Parkinsons Australia, their scores improved, with the average rising over 20 per cent.

Following the seminars, all the doctors said they felt their learning needs had been partially or entirely met, according to medical journal 6minutes.

AAP

ADHD IN PRE-SCHOOLERS: STUDY

Pediatricians are increasingly reluctant to prescribe stimulants for pre-schoolers with ADHD and seem to be turning to less appropriate medications, new research suggests.

In an analysis of NSW records, Sydney University researchers found pre-schoolers had more severe ADHD compared to older children.

Figures showed the number of children under four prescribed stimulants for ADHD dropped from 142 a year in 1997 to 35 a decade later.

About half had been prescribed psychotropic medications of known toxicity and unproven efficacy, medical journal 6minutes reported.

The study authors said these medications don't share the
media stigma and tight regulation of stimulants, which could lead to the perception they're safer.

It's possible the process designed to protect children from inappropriate prescribing of stimulant medication could be indirectly promoting the prescription of medications that are considerably less suitable, they said.

AAP

KEEPING IT IN THE FAMILY

A British teacher is preparing to have her mother's womb transplanted into her in the hope she can have a baby, carrying it in the same womb that carried her.

Sara Ottoson, 25, was born without a uterus because of the condition Mayer-Rokitansky-Kuster-Hauser syndrome, London's Daily Telegraph reported.

Her mother, Eva Ottoson, 56, has agreed to take part in the groundbreaking procedure, becoming the first woman in the world to transplant her womb into her daughter.

The pair hope the complex transplant could take place next spring in Sweden, where doctors in Gothenburg have been assessing suitable patients for the surgery.

If the procedure works Sara, whose condition affects about one in 1500 women, will have her own eggs fertilised using her boyfriend's sperm then implanted into the womb.

The only previous womb transplant occurred in 2000 but it had to be removed 99 days later because of complications.

PA

Ref: 105715160

MEDIA MONITORS

back

AAP Newswire
17-Jun-2011
National
Market: Australia
Market: Australia
Newswire

FLAVOURED MILK OUT OF FAVOUR

The Los Angeles Unified School District has become the largest US school district to ban flavoured milk in an attempt to combat child obesity.

The school board voted this week to eliminate chocolate and strawberry-flavoured milk from schools as of July 1.

Board member Tamar Galatzan was the only board member to object to the milk ban, saying the district was being short-sighted about the nutritional benefits outweighing the added sugar in flavoured milk.

Superintendent John Deasy proposed eliminating flavoured milk after television chef Jamie Oliver brought the issue to the district's attention during recent TV shows.

AAP nap/jfm/jhp

aap

Content Supplied by Australian Associated Press

Ref: 105715160

Pregnant women needed for sun behaviour and diet study

Queensland University of Technology's Centre of Research Excellence in Sun and Health (CRESH) is conducting a research project to investigate the knowledge and attitudes of pregnant women around sun exposure and vitamin D and how this knowledge in turn influences their own sun behaviour and diet.

The research has the potential to provide important information for the future health of Australian mums-to-be and their babies.

We are seeking pregnant women who are 18 years of age or older and who are currently at least at three months gestation to participate in the study by completing a simple, online survey.

To find out more about the study and how to participate, visit **www.cresunandhealth.org.au**. (Please click on the "ENGAGE WITH US" tab at the top of the page to locate the "Knowledge of sun exposure and vitamin D during pregnancy" survey.)

More information Phone Dr Yue Wu on 3138 0330 or email y14.wu@student.qut.edu.au

a university for the real world®

Appendix F

Recruitment Advertisement at QUT Website

Pregnant mums needed for Vitamin D online survey

Date: 14 June 2011

Dr Yue Wu and her daughter. Dr Wu is seeking pregnant women to complete an online survey about their knowledge of Vitamin D and pregnancy.

Vitamin D deficiency can be common in women during pregnancy, even among those living in countries with plenty of sun, which is the main source of the vitamin.

To find out more about their knowledge of sun exposure and vitamin D during pregnancy a QUT PhD researcher is asking pregnant women across Australia to participate in an online survey.

Dr Yue Wu, a paediatrician and PhD student at Queensland University of Technology's (QUT) NHMRC Centre for Research Excellence in Sun and Health, said a previous Australian study had found that 15 per cent of pregnant women were vitamin D deficient.

"This is a disturbing fact because we know that sufficient vitamin D protects pregnant women against hypertension or pre-eclampsia," Dr Wu said.

"There is also some evidence that lack of vitamin D may be associated with the development of gestational diabetes in mothers. Because vitamin D assists with the absorption of calcium, babies born to mothers with low levels of this vitamin are at risk of suboptimal bone growth and low birth-weight.

"Evidence has accumulated that these babies can also run a higher risk of developing asthma and allergic outcomes as a consequence."

Dr Wu said it was unknown whether women's vitamin D levels took a dive during pregnancy because of changes in sun exposure or whether it had to do with the growing foetus's requirements or both.

"I am undertaking this study to shed some light on this issue by investigating pregnant women's knowledge of, attitudes to and behaviour in relation to vitamin D and sun exposure," she said.

"Vitamin D is crucial for both the health of mothers during pregnancy and for healthy growth and development of the baby. The results of this study will be used to develop public health education and intervention to reduce vitamin D deficiency in expectant mothers in Australia and worldwide."

Dr Wu is seeking women all around Australia who are more than three months pregnant to complete an online survey at http://www.cresunandhealth.org.au/engage_with_us/

Media contact: Niki Widdowson, QUT media officer, 07 3138 1841 or n.widdowson@qut.edu.au

Content sourced from QUT News Web Service.

Appendix G

Recruitment Advertisement at Other Websites

Hello there,

My name is Yue Wu from Queensland University of Technology. Recently, I am doing a PhD project in understanding how much pregnant women in Australia know about vitamin D and how they behave in relation to sun exposure and vitamin D.

I'm looking for pregnant women (at least 3 months of gestation, and 18 years and older) to complete a series of online surveys.

Details on the study and how to participate can be found by clicking on the following linkhttp://www.cresunandhealth.org.au/engage_with_us/

Meanwhile, I was wondering if you'd like to help me to pass on my study link to any family or friends that may even be slightly interested!

Many thanks for your consideration of this request.

Kind regards,

Yue Wu

Yue Wu | MD (Pediatrician), MMed,BM
PhD Candidate

AusSun Research Lab
Center of Research Excellence in Sun and Health
Institute of Health & Biomedical Innovation
Queensland University of Technology
60 Musk Ave, Kelvin Grove, Queensland, 4059, Australia
t: +61 7 3138 8662 (share)|m: +61 431 180 765
e: y14.wu@student.qut.edu.au

Appendix H

Follow-up Invitation Letter

Hi XXX (Participant's name),

I'm the PhD student from Queensland University of Technology. Thank you for taking part in my "Vitamin D & Pregnancy" project.

According to your EDD that you wrote down in your first survey, you might have given birth so may I invite you to participate in the follow-up survey which is a part of "Vitamin D & Pregnancy" project?

You can simply complete it by visiting this link: http://survey.qut.edu.au/survey/171399/ba7a/

Or, you can email me on y14.wu@student.qut.edu.au , and then I can send this link to you if you like, it's up to you, for your preference.

It's not as long as the former one, just around 5 minutes. Please help me to complete whenever you think is suitable.

If you have any questions, please don't hesitate to contact me.

Thanks again! What you do means a lot to me.

Warm regards,

Yue

Yue Wu | MD (Pediatrician), MMed,BM

PhD Student
AusSun Research Lab
Institute of Health & Biomedical Innovation
Queensland University of Technology
60 Musk Ave, Kelvin Grove, Queensland, 4059, Australia
t: +61 7 3138 0330|m: +61 431 180 765
e: y14.wu@student.qut.edu.au