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Monitoring Pregnant Women Lifestyle

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ABSTRACT

Pregnancy is a period of change and uncertainties. There is a constant search for information and reassurance that all the changes going through pregnant women's body are normal. Furthermore, during the last years the access to information has increased with the expansion of smartphones and their functionalities and of mobile apps. With this expansion, the concept of mHealth emerged as the use of mobile devices in medicine and public health. mHealth is centred on the patients' care and aims to provide knowledge and empower patients to monitor their health. In cooperation with *Centro Materno Infantil do Norte* a supporting platform for pregnant women was developed called "The 10 moons: pregnancy, childbirth and post-partum period of CMIN". "The 10 moons" goal is to provide pregnant women with access to their pregnancy booklet *Boletim de Saúde da Grávida*, to personalised information and to a set of tools that will allow them to monitor their pregnancy as well as to record appointments and pregnancy-related documents. In order to make it available to the widest range of users, it was tried to use an efficient development approach. Hence, the software development methodology adopted for the implementation of the platform was the one of the Progressive Web App. Overall, the development of the platform was divided into three main areas. This dissertation focus is the pregnancy monitoring and the provision of information in order to promote a healthy lifestyle and avoid complications during pregnancy.

RESUMO

A gravidez é um período de mudança e incertezas. Há uma constante procura de informação e de garantia de que todas as alterações pelas quais o corpo passa durante a gravidez são normais. Além disso, nos últimos anos o acesso à informação tem aumentado com a expansão dos smartphones, das suas potencialidades e das aplicações móveis. Com esta expansão surgiu o conceito de mHealth como o uso de dispositivos móveis na medicina e na saúde pública. mHealth centra-se no cuidado dos pacientes e procura dar aos seus utilizadores mais conhecimento e autonomia para monitorizar a sua saúde.

Em colaboração com o Centro Materno Infantil do Norte foi desenvolvida uma plataforma de apoio às grávidas chamada de "As 10 luas: gravidez, parto e pós-parto do CMIN". "As 10 luas" tem como objetivo fornecer às grávidas o acesso ao seu livro de gravidez Boletim de Saúde da Grávida, a informação personalizada e a um conjunto de ferramentas que lhes permitam monitorizar a gravidez bem como registar consultas e documentos médicos relacionados com a gravidez. Para a sua implementação foi procurado uma abordagem de desenvolvimento eficiente de forma a que a plataforma estivesse disponível para o maior número de utilizadores. Por conseguinte, Progressive Web App foi a metodologia de desenvolvimento de software adotada para a implementação da plataforma.

O desenvolvimento da plataforma foi dividido em três grandes áreas. O grande foco desta dissertação é a monitorização da gravidez e o fornecimento de informação com o objetivo de promover um estilo de vida saudável e evitar complicações durante a gravidez.

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ACRONYMS

- API Application Programming Interface.
- BMI Body Mass Index.
- BSG Boletim de Saúde da Grávida.
- CMIN Centro Materno-Infantil do Norte.
- CPU Central Processing Unit.
- CSS Cascading Style Sheets.
- DGS Direção Geral de Saúde.
- DOM Document Object Model.
- DSR Design Science Research.
- EMR Electronic Maternity Record.
- FAQ Frequently Asked Question.
- GOE Global Observatory for eHealth.
- HIS Hospital Information System.
- HIT Health Information Technology.
- HTML Hypertext Markup Language.
- HTTPS Hyper Text Transfer Protocol Secure.
- IDE Integrate Development Environment.
- IS Information System.
- IT Information Technology.
- JS JavaScript.

- JSON JavaScript Object Notation.
- JSX JavaScript XML.
- LAMP Linux, Apache, MySQL and PHP.
- LDL Low Density Lipoprotein.
- MEAN MongoDB, ExpressJS, AngularJS and NodeJS.
- MERN MongoDB, ExpressJS, ReactJS and NodeJS.
- MVC Model-View-Controller.
- NPM Node package manager.
- ORM Object Relational Mapping.
- OS Operating System.
- PHP Hypertext Preprocessor (originally, Personal Home Page).
- PHR Personal Health Record.
- PWA Progressive Web App.
- REST Representational State Transfer.
- RQ Research Question.
- SQL Structured Query Language.
- SW Service Worker.
- SWOT Strengths, Weaknesses, Opportunities and Threats.
- UI User Interface.
- URI Uniform Resource Identifier.
- URL Uniform Resource Locator.
- UX User Experience.
- VM Virtual Machine.
- WHO World Health Organisation.
- XML Extensible Markup Language.

INTRODUCTION

The work presented hereby aims to describe the development of a *Progressive Web App (PWA)* as a supporting tool for future mothers during their pregnancy. This project was developed in cooperation with *Centro Materno-Infantil do Norte (CMIN)* and the platform, which is called "The 10 moons: pregnancy, childbirth and postpartum period of CMIN", includes three main subjects: answers to common questions and legislation; the pregnancy health record booklet entitled *Boletim de Saúde da Grávida (BSG)*; monitoring pregnancy and information on a healthy lifestyle during pregnancy. Therefore, this dissertation is focused on the third subject – monitoring pregnancy and information on a healthy lifestyle during pregnancy – that incorporates the main project referred, which is being developed with other two colleagues.

This first chapter is divided in three sections. Section one presents a short background describing the relationship between pregnant women and technology. Afterwards, the motivation behind this work, the objectives and *Research Questions (RQs)* for this project development are described on the second section. Lastly, it is introduced this master thesis structure in order to ease its reading.

1.1 BACKGROUND

Whether soon-to-be mom or soon-to-be dad, pregnancy is one of the life events that entails a great need of information. Family and friends, newspapers and magazines, written information from professionals and commercial entities might all be sources of pregnancy-related information. Besides those, all kinds of information are accessible to individuals by means of the Internet [1, 2, 3]. Studies have shown that a large percentage of pregnant women around the world use the Internet as a source of information on pregnancy, complementary to the information from professionals, where foetal development, nutrition and childbirth are the most common subjects among other topics such as delivery complications, pain management and physical

exercise during pregnancy [4]. Nevertheless, the amount of information provided by the Internet on the pregnancy subject could be difficult to handle and, therefore, overwhelming and cause stress [5].

Bjelke et al. (2016) in [5] developed a Swedish study whose purpose was to show how the Internet is being used by pregnant women and the impact it has on them. This study had 183 participants, who more than half were aged 26 to 34, and whose educational level was university. They were predominantly in a relationship and only about 40% of the women were pregnant for the first time. 95% agreed that the main purpose of searching online information during pregnancy was to merely find information. The Swedish study results have also shown that most women seek pregnancy-related information online – being information websites and forum websites the most consulted with 94% and 71,6% of the participants, respectively, using them – weekly.

The previous Swedish study realised that the socio-demographics characteristics of the participants would significantly influence the searched topics [5]. The participants who were pregnant for the first time would read more often information on nutrition, on the new born baby and on physical exercise through pregnancy when compared with the ones who have already been pregnant. The participant's age would influence too, revealing the concern of the older pregnant women (over 35 years old) on the prenatal diagnosis topic. This is understandable since foetal malformations are more frequent among older women [5, 6]. Besides that, the women who have attended parental education classes would search less often information related to the new-born baby and prenatal diagnosis. Furthermore, a huge number of participants, around 65%, said that they felt worried after reading pregnancy-related information searched on the Internet, where forum web pages were the ones that would be causing more worries – on those forums the shared experiences are mainly negative resulting on an unrealistic idea of pregnancy and childbirth [5]. Moreover, almost half of the smartphone users are aged between 18 and 34 years old, which match with the childbearing demographics in most developed countries [1]. An Australian study with 410 participants reported that the three major reasons for using a pregnancy app were to track their own body and to access information about foetal development and about the changes in their body during pregnancy [7]. They also found out that most of the participants felt that the used pregnancy apps were useful or helpful by giving useful information and by helping women to monitor their foetus and the changes in their body. The results have also shown that the participants would enjoy more interactive apps, since on those apps they could store and manage data letting them feel they were personalising the output

of the app [7].

In this context, this master thesis project consists on a development of a *PWA* as a supporting tool for *CMIN* pregnant women. *CMIN* is the *Centro Hospitalar do Porto* hospital unit responsible for neonatology, paediatric, gynaecology and obstetrics. The *PWA*, a cutting edge technology created in 2015, was built using the *MERN* Stack technologies and allowed us to have a fully functional and versatile web app on computers and smartphones of all kinds of *Operating Systems (OSs)*. The research methodology used was the *Design Science Research (DSR)*, which is used on useful and rigorous *Information Technology (IT)* solutions development and assessment. It must also be said that this tool, "The 10 moons: pregnancy, childbirth and post-partum period of *CMIN*", was implemented in cooperation with Patrícia Loreto and Catarina Peixoto, two other students of the *Mestrado Integrado em Engenharia Biomédica*. Besides, this project has three main subjects, as it has already been said. Answers to common questions, legislation, other small features and the main back-end were Patrícia Loreto's responsibility and Catarina Peixoto was entitled to the *BSG*. Thus, the last subject – monitoring pregnancy and information on a health lifestyle during pregnancy – will be the focus of this master thesis.

1.2 MOTIVATION

According to the market search report [8] from 2013, pregnancy apps, aside from being a popular topic among health and fitness and medical categories, were adopted more frequently than fitness apps, which seems reasonable. Through pregnancy soon-to-be moms experience a wide range of emotions since their body changes rapidly and questions are raised while moving over to parenthood and learning how to care for a newborn [1, 7, 2, 3]. According to *Direção Geral de Saúde (DGS)* in [9], women with a low risk pregnancy usually have around 7 medical appointments. In between these appointments, many of them need information and reassurance that what is happening during their pregnancy is normal. The uncertainty, the doubts and the questions they have lead them to a search of information and advice [1, 5].

Since many women who are looking for maternity care and child health services use these kinds of apps and find them a valuable source of information and guidance, healthcare and public health professionals realized that these apps might be considered in the future planning of care provision [1, 10]. Nevertheless, as said on the previous issue of this chapter, all the amount of knowledge provided upon maternal and foetal health, from general pregnancy facts to personalised and gestation-

specific information, may be difficult to handle and increase women's anxiety by offering all these advice and guidance. Furthermore, as well as internet information might be unreliable or even potentially harmful, the reliance on pregnancy apps instead of a health professional could be a cause of concern along with the validity and credibility of the information provided [1, 7].

The present work seeks to integrate some features on the main project in order to display pregnancy-related information supported by CMIN without overwhelming the users with unnecessary details and to encourage women to self-monitor their pregnancy. Besides being developed in cooperation with CMIN, the present work has added value and it is their interest to provide an app which will support their patients during pregnancy. Additionally, this project will be used by CMIN as soon as it is concluded.

1.3 OBJECTIVES

The main aim of this work is to implement a supporting tool for CMIN pregnant women. This assistance would be provided by a PWA which will give access to the pregnancy booklet BSG, to a set of FAQs and legislation, to pregnancy-related information and advice on health. It will also allow future mothers to store documents and record appointments. Therefore, the following RQ and objectives to respond to these questions were established. The first three RQ are related to the platform implementation phase.

RQ 1 How is it possible to develop a website and a cross-platform mobile app efficiently?

- Analyse the different types of mobile development.
- Analyse the different technology stacks for the chosen type of mobile app.

RQ 2 How is the platform going to monitor future moms during their pregnancy?

- Give weekly information on foetal development.
- Give pregnancy related information, such as changes on pregnant woman's body, nutrition, physical activity and other tips based on gestational age and on the BSG.
- Develop a pregnancy log.

- Create a monitoring tool to track gestational diabetes.

RQ 3 How can the *User Experience (UX)* given by the implemented supporting tool be enhanced?

- Create a responsive interface.
- Make the platform usable even when the user is offline.
- Create a dashboard to ease the user's interaction with the platform.

The second phase of the project focuses on the validation of the system developed for the **CMIN** pregnant women. Therefore, the following two **RQ** are intended to evaluate and to propose improvements.

RQ 4 What is the viability and usability of the developed platform and its utility for its users (the future mothers)?

- *SWOT* Analysis of the developed supporting tool.
- Usability Test execution to assay the developed supporting tool.

RQ 5 How and where can the new platform for pregnant women improve?

- Elaboration of modifications and improvements propositions since it is hoped that the work presented hereby is continued, maintained and expanded.

1.4 DOCUMENT STRUCTURE

The presented document is structured in seven chapters.

Chapter 1 – Introduction: This chapter presents the context of this project introduced by a background about the pregnancy and technologies relationship. It also presents a small overview of this project development and the entities, people, methodology and technologies involved. Still on this chapter, the motivation, the **RQ** and the aims of this project are also explained.

Chapter 2 – State of the Art: Here, the concepts related to the project are explored through three main issues. The first one is about the mobile development. This subject is introduced by a short elucidation of the cross-platform mobile development difficulty and followed by a description of the three types of mobile apps – native, web and hybrid apps – and the *PWA* technology. Then, the mobile health section brings concepts like *Personal Health Record (PHR)* and, obviously, mHealth. The advantages and disadvantages of mHealth are also explored and examples are given. At the end of this section it is explained and demonstrated how important the *UX* is to the mHealth users. Lastly, the State of the Art provides a summary of six pregnancy apps which are currently at the top results of Google Play and App Store. Moreover, the advantages of the developed tool, when compared with the previous six apps, is displayed.

Chapter 3 – Research Methodology and Technologies: The methodology adopted for the development was the *DSR* which is indicated for *IT* solutions. This methodology is described in the first section of this chapter and its guidelines are presented. The following section justifies the choice of stack made for the development. Then, all the technologies used – MongoDB for the database, Express.js and Node.js for the back-end, React for the front-end – are also described.

Chapter 4 – Supporting Tool for Future Mothers During Pregnancy: In this chapter, the developed platform during this master's thesis is described. It starts by presenting the requirements which were established by *CMIN* and the features added to enrich the platform. Following the first section of this chapter there is the system architecture, where it is explained how the *MERN* Stack technologies interact with each other. Here is also explained how the web app, which was initially implemented, is converted to a *PWA* and the advantages of this transformation. Eventually, the components on which this work is focused are closely described. Therefore, this chapter ends with the description of the six modules implemented for the main project. The User's Home Module is the platform dashboard. The Health and Well-being Home Module introduces the health tips and pregnancy related information by giving access to the Pregnancy Log, Foetal Development and Advice for Future Moms Modules. There is also a module aimed at monitoring gestational diabetes or diabetes mellitus: Gestational Diabetes Record Module.

Chapter 5 – Discussion: This chapter is used to make an overview of the development of the supporting tool, starting on the choice of the type of mobile app until the six modules which are described on this dissertation. The choices made

are discussed and, for a better reading, this chapter is divided in two sections: the discussion made on the choices of the mobile development and technologies and the discussion made on the supporting tool development.

Chapter 6 – Proof of Concept: The aim of the proof of concept is to demonstrate the feasibility of what has been developed. In order to do that, this chapter has two main sections: the *SWOT* Analysis and the Usability Test. The first section describes the concept of the *SWOT* Analysis and applies it to the developed tool. The strengths and weaknesses of the platform are identified as well as the external factors that might influence positively and negatively the adoption of the developed tool. The second section, the Usability Test, suggests a usability test that might be implemented on the platform. Unfortunately, there was no time to implement one and analyse its results.

Chapter 7 – Conclusion and Future Work: This is the last chapter of this dissertation. Here the main contributions are presented by answering the *RQ* introduced on Section 1.3 and, through this, a summarized overview of all the work developed is made. Still, on this last chapter, the possible directions for the future work to allow this project to be continued, maintained and expanded are presented.

STATE OF THE ART

On this second chapter the state of the art of the terms and concepts mentioned or related to the development of this project is presented. This chapter is divided in three main issues: "Mobile Development", "mHealth" and "Pregnancy Mobile Apps". The first one, "Mobile Development", is intended to present the challenge of developing a cross-platform mobile app, the types of mobile apps currently existing and, lastly, the solution found and that is implemented on this project - the [PWAs](#). Thereafter, the concept of mHealth, the second issue, comes with its advantages, disadvantages and three examples of its impact on patients with cardiovascular diseases. Also in this issue, it was chosen to mention the importance of [UX](#) to lead the users to adopt mHealth technologies on their day-to-day life. The last issue, "Pregnancy Mobile Apps", analyses six pregnancy apps currently available at stores and compare their features to what was proposed to do on this thesis.

2.1 MOBILE DEVELOPMENT

Year by year, the number of smartphone users has been growing, and yet their [OS](#) isn't the same for all, being Android, iOS and Windows Phone the most ordinary. When developing a mobile app, the main goal is to reach as many users as possible and, since the [OSs](#) aren't compatible with each other, that means developing the same app for each mobile platform [11]. On Table 1 it is shown the predominant differences between the two main [OSs](#) (Android and iOS), which must be taken into consideration when implementing an app [12, 13].

Table 1.: Main differences between Android and iOS operating systems (based on [12, 13]).

	iOS	Android
<i>Virtual Machine</i>	No	Dalvik <i>VM</i>
Programming Language	Objective-C	Java
User Interface	Cocoa Touch	<i>XML</i> files
Memory Management	Reference counting	Garbage collector
<i>IDE</i>	XCode	Eclipse (2013)
Platform	Mac OS X	Multi-platform
Devices	Homogeneous	Heterogeneous
App market	iTunes Apps Store	Google Play Store

It is easy to notice that between iOS and Android the programming language, user interface, memory management, *IDE*, platform and so forth are all different. Perchat et al. (2013) give in [12] two more particular examples of the struggles of developing a mobile cross-platform application: the developer may use a navigation controller – a container view controller that manages the navigating hierarchy of the content since only child view controller is displayed at each time [14] – on iOS platforms, but that cannot happen on Android; and certain notions like using intent processes to launch certain actions applies on Android platforms but not on iOS. Mobile apps can be divided based on the technology that was used to create them and also based on the OS where they are capable of running on. Thus, there are three types of mobile apps: web app, native app and hybrid app [11].

2.1.1 Web App

This first type of mobile app is implemented by using web technologies – like *HTML* 5, *JavaScript (JS)* and *CSS* –, hosted on remote servers and served via standard protocols. They are mobile-optimized websites which will use the web mobile browser. Their processing is done on the server and only the user interface is rendered on the mobile [11, 15].

The main advantages of this type of app are the technologies used to implement them, *HTML* 5, *JS* and *CSS*, which are technologies easy to learn and develop. Therefore, the amount of time and effort to develop an app for the various OSs is lower [11]. By using the web mobile browser to run and with all the processing done on the server, these apps only need to be developed once. They will also be able to run on different OSs and will offer a uniform experience across platforms

[15]. Additionally, these web apps as well as their data are simple to update [11]. On the other hand, the web apps can't be available at any store. They are accessed by entering the *Uniform Resource Locator (URL)* on the mobile web browsers. This also means that they need internet connection to run the app [11, 13].

2.1.2 Native App

Mobile native apps are created with the tools and programming language characteristic of a certain platform, thereby they are developed for a specific operative system [11]. They are available at the corresponding stores from where they can be downloaded and, then, stored locally. Lastly, they have access to all the device hardware and software [11, 15].

On the one hand, the native apps characteristics lead to some advantages. Their performance is higher than any other type due to being developed directly upon the mobile platform services and the platform-specific *Application Programming Interface (API)* [11, 15]. The access to the device hardware and software will allow native apps to take advantage of the look and feel of the OS – the design and behaviour of the *User Interface (UI)* is characteristic of the OS – and, thereby, creating a good UI [11, 13].

The main setbacks are related to the developing time, cost and effort. Firstly, developing a native app is a lot harder than developing a web app and it takes a higher level of experience. Moreover, each OS requires a different version of the same app, because the code used on one mobile platform cannot be used on another. This results on an increasing of the developing and maintaining time, cost and effort [11, 15].

2.1.3 Hybrid App

This third type of mobile app is a mixture of the best parts of the two referred behind. The mobile hybrid apps are implemented with the same standard web technologies used to develop a mobile web app – making them structurally similar and their UI can be reused on different OSs – along with being rendered inside the native app [11, 15]. They are also developed with a hybrid development framework. With this tool, developers are given access to a web-based code wrapper and also to a generic *JavaScript API*. This last one, the generic *JavaScript API*, will work as a cross over between the web-based code and the corresponding platform API [15]. Hybrid apps, like native apps, are available at stores [11, 15].

The main advantage is the possibility of creating a cross-platform web-based mobile app as well as being used for server back-end or for standalone app [11, 15]. Likewise the mobile web apps, when used for server back-end the data will be stored on the server and, thereby, they will have a smaller size. Besides, they are easy to develop and maintain [11].

On the other hand, the main setbacks are the performance, the limited number of APIs and the lack of look and feel at the UIs. When compared with the native apps, the hybrid apps performance is lower. Secondly, the number of APIs provided by the wrapper is only a subgroup of all the possible APIs provided by each OS [15]. Finally, the UIs lack look and feel. However, it is possible for hybrid apps to achieve the look and feel of the OSs [11].

2.1.4 Progressive Web Apps - the cutting-edge technology of mobile web apps

PWAs, a technology that was introduced in 2015, belong to the category of web apps whose aim is to heighten the mobile web experience by seizing the new features supported by the modern browsers. The first time accessing to the PWAs is through the browser as a classic web app. Only then can the user decide to install the PWAs in the device and benefit from a mobile web experience improved on conversions, reliability, performance and engagement [15, 16].

Before explaining the reasons why the mobile web experience is improved with PWAs, the technical foundation behind PWAs must be introduced: the Service Worker API. These Service Workers (SWs) are a JS file that runs in parallel with the main browser thread. They allow developers to programmatically cache and preload assets and data as a client-side proxy, to manage push notifications, background sync, among others. Therefore, for a mobile web app to be classified as a PWA it must be served over Hyper Text Transfer Protocol Secure (HTTPS) (which is a request for the use of SWs, coming with a web app manifest – it is a JavaScript Object Notation (JSON) text file with information about the app (short_name, name, icon and a start_url) – and use one SW at least [15, 16, 17]. Only when matching these conditions and the web app is visited at least twice and more than five minutes apart, a banner will appear and ask to install the PWA [17].

The first point where PWAs were improved was on conversions by using the web design strategy of progressive enhancement. This strategy uses the basic content and functionalities of the webpage as first layer. Afterwards, it adds more functionalities depending on the users' browser and internet connection. The reliability comes from the fact that, unlike the standard web apps, the PWAs work with low

or no network connectivity. The dependence on network is erased as well as the performance is augmented due to the fact of having a SW running on the background as described on the previous paragraph. PWAs can also be installed on the device and accessed from an icon on the home screen. Adding the possibility of push notifications and running in a full-screen mode to the icon on the home screen, we have a set of mechanisms to engage the users [15, 16].

2.2 MHEALTH

The traditional healthcare processes have become obsolete [18]. With all the advancements in healthcare practice, the demand for electronic health systems, also known as eHealth systems, has grown [19, 18, 20]. Moreover, *Health Information Technology (HIT)* has grown to be a strong area of *Information System (IS)*. Socio-economic and technical developments on the health care sector are the main causes behind this growth. With the population ageing and the increase of chronic diseases, the costs on health care have also enlarged. However, storing, sharing and analysing health information as well as using software and infrastructure on medicine and clinical practice, which are part of *HITs*, might reduce these costs and raise the health access, quality and outcomes [21, 20, 22].

2.2.1 Personal Health Records and mHealth

PHRs aim to provide the patient with the ability to safely and confidentially access, manage and share their health information [23, 24]. *PHRs* supply patients and healthcare providers with a complete summary of patients' health history. They also empower patients to have a more active role on their own health, to improve their health literacy with complete and accurate health information, to make better communications with their healthcare providers and to practice preventive self-care routines [24, 25, 26, 27, 28]. Thus, the healthcare costs are reduced [29].

Along with the enhancement of mobile phones functionalities and computing capabilities, with their constant presence in our day-to-day life, the expansion of medical apps came out [30]. The notion of mobile Health (mHealth), a sub-segment of eHealth, as the use of mobile devices in medicine and public health to deliver health interventions has emerged [31, 32]. In their 2011 report in [33] the *World Health Organisation (WHO)* stated that their *Global Observatory for eHealth (GOe)* defined mHealth as "medical and public health practice supported by mobile devices, such as mobile phones, patient monitoring devices, personal digital assistants (PDAs),

and other wireless devices". mHealth encompasses not only simple strategies like the use of short message service, SMS or text message, but also more sophisticated strategies such as apps that might use external devices like medical sensors or smartphone resources like camera, allowing most of the patients and users to be involved in their own health care [30, 34, 33].

2.2.2 *The mHealth pros and cons*

In order to be used by healthcare systems, mHealth apps must meet some security requirements. There is a long list of threats that mHealth apps face, from privacy threats – identity theft and disclosure threats among others – to leakage of information and to data-stealing and data-injection attacks resulted from the use of external devices. Storing unencrypted data on smartphone external storage, a usual application procedure, is also dangerous since the user's data stored on external storage might be accessed by any other application with permission to access external storage [30].

However, there are many more advantages with the use of mHealth. It is a strong health behaviour tool which adds value to health care professionals and patients by reducing the healthcare cost and increasing the patient's satisfaction as well as the healthcare services and professionals' efficiency. mHealth leads to a patient-centred healthcare model [30, 34, 27]. Not only health professionals are able to monitor their patients' health through mHealth, but also these same patients and users are empowered to monitor their own health related problems or even to understand certain medical condition [30, 27].

2.2.3 *mHealth examples*

In [35], the "mHealth in Cardiovascular Health Care" 2016 review, the impact of text messages mHealth intervention to prevent cardiovascular disease is shown. A New Zealand trial with 9100 smokers has demonstrated that receiving simple text messages interventions would double the odds of quitting smoking in the following six months [36]. Moreover, in Australia, a trial [37] with 710 patients with coronary heart disease was conducted. This trial addressed multiple cardiovascular risk factors and patients would receive four text messages each week for the following six months. The results after this six months period have shown that the ones receiving these text messages interventions – which were personalised with patient's

name and information on smoking, physical activity, diet and general heart health – would have lowered *LDL*-cholesterol, systolic blood pressure and *Body Mass Index (BMI)*. Besides, a larger percentage of these patients became physically active and had quit smoking [37]. Furthermore, Widmer (2015) in [38] also conducted a study with coronary heart disease patients, whose aim was to assay the impact of a mobile app on patients' weight, blood pressure, lipids, exercise capacity, rehospitalization and emergency department visits. Both experimental and control group would have access to the traditional cardiac rehabilitation, yet the experimental group would also have access to a mobile app for the three previous or following months of rehabilitation. Therefore, the experimental group has presented a significant improvement in systolic blood pressure, weight, lipids and exercise capacity. The rehospitalizations as well as the emergency department visits were lower on the experimental group.

2.2.4 *The importance of user experience on mHealth*

Nowadays, web sites and apps should be more than a product for specific users to achieve certain tasks. Their success not only depends on what they do, but also on how they do it and how they are perceived by its users. For them (users), the value of an interactive product is reflected on how it satisfies their needs in a specific situation [39, 40, 41]. Although *UX* attributes and relationships are a scope difficult to understand and assess, human-computer interaction researchers have acknowledged the importance of this *UX* – the experience given by a product, system or service to its users through interaction [39, 41, 42]. mHealth apps are no exception. Their success depends on their usability – how well it is being used by their users – and on their users' experience. The only way of leading users to adopt these mHealth apps is by ensuring a good *UX* [31, 43].

Diabetes mellitus, type 1 and type 2, is a common condition to many people of all ages and their patients must be daily monitored [44]. Consequently, there is a great number of apps on this subject which are built to be trendy and with fast responding abilities. Clearly the target audience of these apps are the youth with diabetes. However, the vast majority of people affected by this disease are aged 50 or older and most of them are unwilling to use these apps. The reason behind this is that for them, the elderly, those apps are neither easy and appealing to use nor useful and motivating. Having these as their starting point, Kalimullah and Sushmitha (2017) have shown the importance of *UX* on mHealth by adapting an app for elderly people diagnosed with diabetes mellitus. In their study, to the

control group was given Glucosio app and to the experimental group a simpler version of this Glucosio app. In this simpler version of the app, the changes on the UI, for instance displaying one button only to view their readings instead of having to navigate between different menu options, has increased the UX of the elderly users [43].

2.3 PREGNANCY MOBILE APPS

Electronic Maternity Record (EMR) are a specific type of PHRs used for maternal care. EMRs are usually a way of exchanging pregnant women's health data between healthcare providers such as obstetricians, nurses and nurse-midwives. Providing future moms access to a summary of their maternity records would calm them and make them more comfortable during their pregnancy as well as informed [45, 46]. The expansion of smartphones and mobile apps has been enormous and taking advantage of those tools to develop a mobile app for pregnant women, which has an EMR integrated, might be an efficient and easy way to provide antenatal care and to monitor pregnancy.

Lupton and Pedersen (2016) in [7] divided the pregnancy apps on three categories, where one of them was about pregnancy and foetal monitoring and the others two were "pregnancy information" - with information on foetal development, nutrition, exercise and health behaviours - and "entertainment". The apps of the first referred category would encourage women to monitor their:

- Weight, waist measures and foetal movements;
- Diet and water consumption;
- Symptoms, moods, cravings, energy levels and sense of hunger.

In 2016, Bachiri et al. in [31] led a study where 33 pregnancy mobile apps were analysed. At the end they concluded that to have an accurate and complete pregnancy tracker the pregnancy mobile apps should contain the greatest amount of areas of pregnancy. They have also reached the conclusion that the features of the mobile pregnancy apps must be adapted to their users needs. Therefore, here are presented some apps which belong to the categories "pregnancy and foetal monitoring" and "pregnancy information". The following apps were chosen from the stores Google Play and App Store top results when searching for pregnancy-related apps.

Table 2.: Examples of pregnancy apps currently available at stores.

Name	Description	Main Features	OS
What to Expect - Pregnancy & Baby Tracker	A pregnancy tracker app which gives daily and weekly information on the foetus development, tips and articles based on the due date.	<ul style="list-style-type: none"> - Birth date calculator based on the first day of the last menstruation or on the conceiving date; - Videos showing the weekly changes of the baby; - Tips on healthy eating, sex and common symptoms during pregnancy; - Suitable for moms, dads, caregivers or relatives. 	Android and iOS
BabyCentre - My Pregnancy & Baby Today	A pregnancy tracker app which gives weekly tips. It gives access to videos, articles, baby essentials and health solutions.	<ul style="list-style-type: none"> - Birth date calculator based on the first day of the last menstruation; - Birth date countdown; - Weekly information on foetal development and mother's body; - Suggestions and tips about healthy habits; - Belly pictures; - Contraction timer; - Forum community. 	Android and iOS
Pregnancy +	A pregnancy tracker app which gives weekly tips.	<ul style="list-style-type: none"> - Birth date calculator based on the first day of the last menstruation or on the conceiving date; 	Android and iOS

	It gives access to videos, articles, baby essentials and health solutions.	<ul style="list-style-type: none"> - Birth date countdown; - Weekly information on foetal development and mother's body; - Suggestions and tips about healthy habits; - Doctor appointments and tasks records; - Belly pictures; - Contraction timer; - Foetal movement counter; - Weight monitoring; - Birth plan; - Information on food, labour, physical activity and breastfeeding. 	
WomanLog Pregnancy	A pregnancy calendar where it's possible to record pregnancy information each day.	<ul style="list-style-type: none"> - Birth date calculator based on the first day of the last menstruation or on the conceiving date. It has also the option of inserting the schedule due date. - Birth date countdown; - Weekly information on foetal development; - Calendar with: contraction timer; foetal movement counter; medical appointments and moods records; weight, waistline size and symptoms monitoring. 	Android
Wellness for 2: Pregnancy	A pregnancy tracker.	<ul style="list-style-type: none"> - Birth date calculator; - Information on foetal development, on changes 	iOS

Wellness Toolkit
for Mom & Baby

- on mother's body and advice;
- Exercise, symptoms, weight, waist measurements, meals and water intake tracker;
- Foetal movement counter;
- Contraction timer.

Ovia Pregnancy
Tracker & Baby
Countdown
Calendar

A pregnancy tracker app that gives daily and weekly information on the foetus development, tips and articles based on the due date.

- Birth date calculator based on the first day of the last menstruation, or on the conceiving date or even on the pregnancy duration;
- Birth date countdown;
- Weekly information on foetal development and mother's body;
- Suggestions and tips about healthy habits;
- Calendar to record doctor appointments, notes and milestones;
- Contraction timer;
- Foetal movement counter;
- Weight and blood pressure monitoring;
- Moods, symptoms, physical activity, medication, sleep, meals and water intake tracker;
- Health assessment (health history);
- Health alerts.

Android
and iOS

Overall, "Ovia Pregnancy Tracker & Baby Countdown Calendar" is the closest version to the aim of this thesis. Besides all the common features to the other apps, it also collects information analogous to the data that pregnant women must record on their booklet [BSG](#). This feature is called "health assessment" and it records information such as the number of babies at the current pregnancy, the existence of gestational diabetes in a previous pregnancy, family history, conditions (zika, aids, syphilis, toxoplasmosis, herpes, hepatitis B or C), autoimmune diseases, medication to help prevent preterm birth or other medication, etc. Then, it supposedly personalises the app providing informative articles with the data collected in the "health assessment". Besides, it has a great user interface and it gives, on the whole, a good [UX](#). However, there isn't a Portuguese version of this app yet, it does not work offline denying its access to the users and, even when the user states that has diabetes or gestational diabetes and has to take insulin, it doesn't provide a tool to monitor blood sugar nor insulin doses.

All the previous six apps need the user to insert her due date, otherwise the user cannot have access to it. Although all of them have interesting [UIs](#), they have limited features. "What to Expect - Pregnancy & Baby Tracker" and "BabyCentre - My Pregnancy & Baby Today" are both mainly just informative apps, but they lack personalisation. To ensure a bigger [UX](#) it would be necessary to use them along with a monitoring app like "WomanLog Pregnancy". "Pregnancy +" could be a solution, like "Ovia Pregnancy Tracker & Baby Countdown Calendar", to give a better [UX](#) by having an app that displays pregnancy-related information. It also lets the user monitor its pregnancy and is more customized. However, the monitoring is limited to record the weight and foetal movements and it doesn't take advantage of the data collected to alert the user if needed.

The main difference and advantage between the previous apps and the supporting tool here proposed for future mothers during pregnancy is that it was implemented with the [PWA](#) methodology. This methodology will allow our app to be available to a higher range of users, with less developing time, cost and effort than the native apps. The advantages of the [PWA](#) over the web apps are obvious and they may seem a viable alternative to hybrid apps. Moreover, [PWA](#) will also work on computers without extra developing time, which neither hybrid apps nor native apps are able to. Clearly, [PWAs](#) are more advantageous than any other type of mobile app (native, web or hybrid app).

Furthermore, the app here proposed has a set of useful features for pregnant women and all these features make it a more complete supporting tool than the ones previously presented. This app will allow users to have access to an [EMR](#).

There they can record more safely the same health information that they would record on their pregnancy health record booklet as well as their weight, their blood pressure and the foetal movements. Users will also have access to a more complete calculator of the due date than the ones used by the previous apps. Pregnant women are able to record appointments and save medical exams that they might have done. Besides, all the doubts that they might have are answered by a set of previous, during and after pregnancy FAQs.

Finally, the app will provide an optimized and customized experience due to be based on the recorded data [47]. Thus, the developed app has a set of features which will allow monitoring pregnancy, enhance the UX and make it more user friendly than the ones previously presented. This part of the app is also the focus of this thesis. These features encompass the foetal development information, the diary where pregnant women can record, for instance, what they have eaten, information on the changes of the mother's body, articles suggested based on the health history of the user, record blood sugar levels in case of having diabetes or gestational diabetes, among others features. The user friendly characteristic is granted by the dashboard home screen that makes it easier for users to find information, the main monitoring tools and a birth date countdown. In conclusion, the app here proposed is a more complete and accurate pregnancy tracker than the previous ones.

RESEARCH METHODOLOGY AND TECHNOLOGIES

Before developing the platform, a long and exhaustive analysis of the methodologies and technologies viable and available at the present time was made. The technologies were selected based on their advantages, on how suitable they were to achieve our aims and needs and on the *UX* they would provide. Therefore, it was chosen to use one of the two most popular stacks: the *MERN* Stack. Behind this stack of various technologies is one and only programming language. By having *JS* as the only programming language, the development time and cost is reduced and the efficiency is improved. For instance, different programming languages don't have to be understood to develop the front-end as well as the back-end [48].

This chapter is divided in six sections. It starts by introducing the research methodology chosen: the *DSR* methodology. This is used on the building and assessment of useful and rigorous *IS* solutions. Afterwards, the choice of the stack is explained and compared to two others: the old-school *LAMP* Stack and the direct contestant *MEAN* Stack. The following four sections describe the four technologies used on the development of this project and which form the *MERN* Stack: MongoDB, Express.js, React and Node.js.

3.1 DESIGN SCIENCE RESEARCH METHODOLOGY

The hardware, software and human interfaces of the *IS* are constantly changing and adapting. From this challenge the *DSR* methodology has emerged. The *DSR* can be defined as a problem-solving paradigm, which is having great impact on Engineering and Computer Science areas [49, 50]. It is a strict process that aims to produce knowledge: to design artefacts to solve a problem, to assess what was designed and what is functioning and to share the achieved results [51]. These artefacts might be instantiations (implemented and prototype systems), constructs (vocabulary and symbols), models (abstractions and representations) or even methods (algorithms and practices). Besides, the knowledge produced by the *DSR* comes from a rigor-

ous method of scientific research and the improvement of the artefact relevance and utility is fundamental [52].

Figure 1.: Schema of the DSR methodology appliance to IS which combines behavioural-science with design-science (based on [52]).

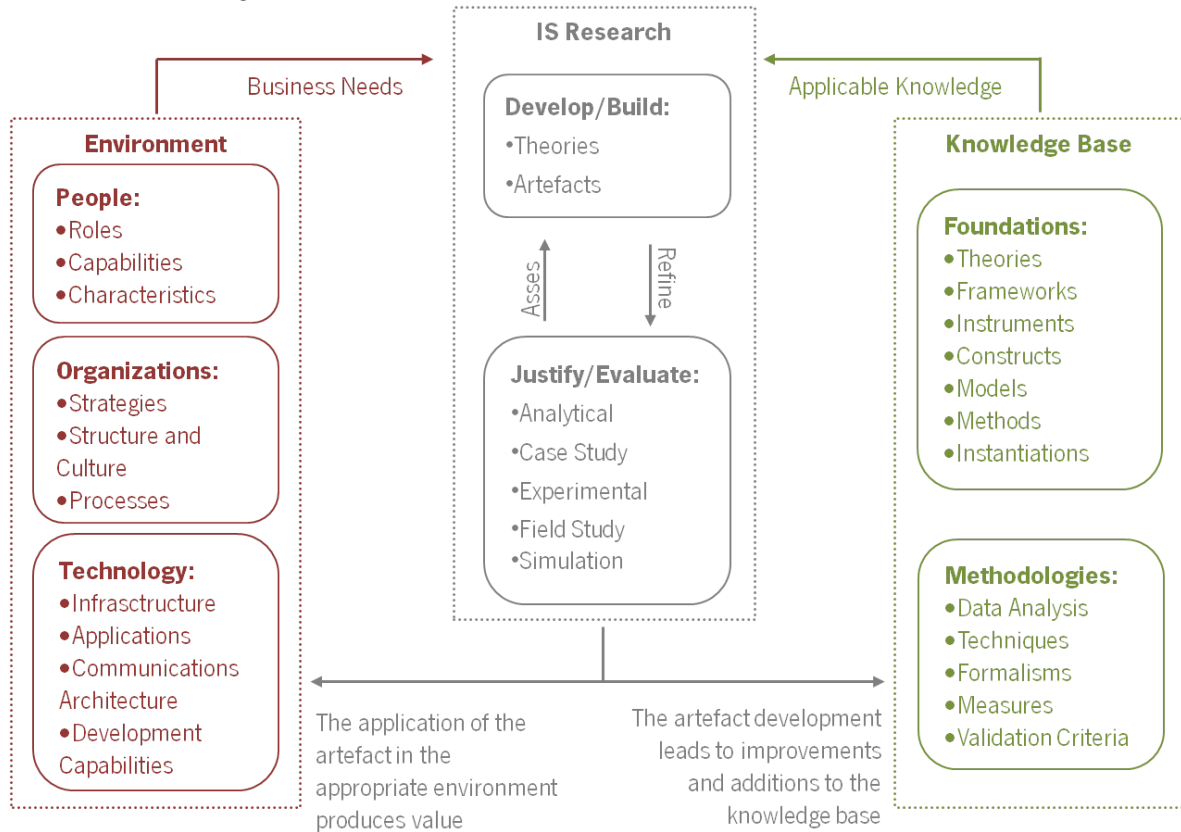


Figure 1 represents the DSR methodology. The problem space is defined by its environment and its aims, problems, opportunities and tasks clarify which are the business needs or problems. The research relevance is guaranteed by having research activities that respond to the business needs. The research oscillates between two phases: the develop/build and the justify/evaluate phases. The research assessment is made through the justification of theories and the evaluation of artefacts. After the identification of weaknesses, the developed theories and the built artefacts are refined and reassessed. The information on refinement and reassessment is usually outlined in future research directions. Lastly, the knowledge base, which encompasses the foundations and methodologies, provide the raw materials required by the IS research [52]. Based on this, seven guidelines should be followed to conduct a good DSR within IS [49, 52]:

1. *Design as an artefact*: when applying the **DSR** methodology to any **IS**, the result must be a viable and useful artefact. It must be an instantiation, a construct, a model or even a method implemented on the development and use of the **IS**.
2. *Problem relevance*: the technology-based solution found and implemented by the **DSR** paradigm must be to important and relevant business problems.
3. *Design evaluation*: the design utility, quality and efficacy for the problem is ensured by its evaluation. The environment where the artefacts are implemented set up the evaluation requirements.
4. *Research contributions*: the artefact must find the solution to a problem that hasn't been solved yet or come up with a more effective one. Either way, a new research contribution is formed by the artefact. There are three types of research contributions: the design artefact, the foundations and the methodologies. The foundations represent the improvement of the existing **DSR** knowledge that comes from the artefact development. The methodologies encompass all the evaluation methods and evaluation metrics contributions.
5. *Research rigor*: the construction and evaluation of the artefact is required to be based on rigorous methods.
6. *Design as a search process*: the **DSR** must be an iterative process, cycle oscillating between generating design alternatives and testing these alternatives.
7. *Communication of research*: the results obtained from the **DSR** methodology should be shown to technology-oriented audiences, which will enable the implementation of the artefact and the right use of it, and management-oriented audiences, which will determine the commitment of the organisational resources to the artefact construction and use.

The implemented **PWA** which is described on this document follows the **DSR** methodology. The found solution meets the **CMIN** requirements, which will be explained on Chapter 4, and the pregnant women's needs. It is an appropriate and valid solution, supported by adequate technologies, while taking into consideration the today's challenges of cross-platform mobile development. Also, the **PWA** referred was properly evaluated through a **SWOT** analysis.

3.2 WHY MERN STACK?

Nowadays, there are a many technologies and stacks available for web development. For example, Java Web Apps and stacks such as *LAMP* have been widely used until now [48]. *LAMP* is an old-school stack, being popular since 2000, and stands for: Linux, the Unix-like *OS*, which runs on various types of computer hardware; Apache Web Server; *MySQL* as relational database management system; and *PHP* for rendering view and control (*PHP* alternatives are Perl and Python) [48, 53]. All these technologies are free and open-source making this stack appropriate for dynamic web sites and web apps. Despite being a popular stack, it isn't quite easy to learn and has been challenged by other stacks [48, 54].

Two of these other stacks which have emerged a few years ago and have been largely adopted are the *MEAN* and the *MERN* Stacks. The *MEAN* Stack — MongoDB, Express.js, AngularJS, Node.js - was one of the first stack to embrace the concepts of Single-page Application and NoSQL. Single-page Applications are web apps whose interaction with the user is made through rewriting the presented page instead of loading brand new ones. All the technologies used on this stack are managed by JS. This programming language is easy to learn, to write and to understand the data flow between the client and the server [48].

As it can be noticed, *MEAN* and *MERN* Stacks are extremely similar. However, the *MEAN* Stack uses the front-end framework AngularJS. It is based on the *Model-View-Controller (MVC)* design pattern and, for this reason, the load on the server is reduced by differentiating the client side from the server side. However, with the growing complexity of the apps, the cascading of updates on the Views coming from the changes on Models have become hard to maintain. This led to the development of React, five years ago, and consequently the appearance of the *MERN* Stack [48].

After being taken into consideration the differences between *MERN* and *MEAN* Stacks (see Table 3), the *MERN* Stack has been chosen. Its technologies are described on the following sections.

Table 3.: Main differences between MEAN Stack and MERN Stack (based on [48]).

Attribute	<i>MEAN</i> Stack	<i>MERN</i> Stack
DOM	Regular DOM	Virtual DOM
Learning Curve	Weak	Strong
Packaging	Weak	Strong
Debugging General	Good <i>HTML</i> / Bad <i>JS</i>	Good <i>JS</i> / Bad <i>HTML</i>
Fail	Runtime	Compile-time
Binding	Two-way	One-way
Template	In <i>HTML</i>	In <i>JSX</i> files
Mobile Development	Ionic Framework	React Native
<i>MVC</i>	Yes	View layer only
Rendering	Client side	Server side

On Table 3 it is stated that the *MEAN* Stack learning curve is weak. Although it has comprehensive documentation, Angular is the most complicated one to learn. The distinction on the attribute "packaging" is explained by the number of packages available for React, even though the *npm* ecosystem is available for everyone. Related to "fail", checking for typographical errors works better at the compile-time than at the runtime. As far as "binding" is concerned, by being two-way binding the model state is changed when the *UI* element is updated in *MEAN* Stack. This is cleaner and easier to implement. However, *MERN* Stack is one-way binding, which means the model is updated firstly and only then the *UI* element is rendered [48, 55].

3.3 MONGODB

Although *MySQL* is one of the most popular databases, MongoDB was the database chosen to store and handle all the users' information. MongoDB is a *NoSQL* document-oriented database with a flexible schema and a *JSON*-based query language. In other words, the same set of fields don't need to be present in all the collection documents and all the operations on documents are specified on a *JSON*-object. All the information on each document (of every collection) can be accessed through a unique identifier [56, 57].

There are two main differences between *NoSQL* databases and the conventional ones. Nowadays users' data that needs to be stored in web-oriented systems can scale to terabytes every day. Their databases should be able to fulfil this need and still make all the data available to millions of users under low latency requirements.

NoSQL databases, through the distribution of the load over multiple servers, are able to horizontally scale by sacrificing their consistency [56, 58]. Secondly, these storage alternatives like MongoDB are not based on relational models. The persisted data can be seen as objects or documents, avoiding the need of a translation layer such as ORM layers [56, 58]. The disadvantages of MongoDB are overcome by its advantages, as it can be seen on Table 4.

Table 4.: Some pros and cons of MongoDB [48].

Advantages	Disadvantages
<ul style="list-style-type: none"> - Schema less; - Clear object structure; - Supports deep queries; - Highly scalable; - Non requirement of conversion/mapping of application objects; - Use of internal memory to store working set, enabling faster data access. 	<ul style="list-style-type: none"> - Gigantic data size; - Less flexibility in running queries; - No transactional support.

3.4 EXPRESS.JS

Express.js is the web server framework adopted to simplify the writing of server code [56]. It is a minimalist framework for Node.js and the Node.js middleware module, which implements http module, was used to design Express.js [48]. It allows defining routes which will have an associated function to respond to the arrived HTTP users' request [56, 59, 60]. Therefore, Express.js will work as a middleware. At the request side it parses URL, headers, bodies and parameters. On the other hand, the functionalities required by the web applications are at the response side. Here it is possible to set response codes and cookies, manage sessions and send custom headers among others [56, 60]. Besides, a MVC pattern is given by Express.js to web apps. It allows the development of scalable applications through efficient code reuse and web app parallel development [60]. Overall, Express.js has a set of advantages which some of them are [48]:

- The development of a Node.js web application is much faster and easier;
- The configuration and customization is extraordinarily easy;
- Defining routes based on HTTP methods and URLs is allowed;

- The *RESTful API* server generation is enabled;
- Error-handling procedures are supported;
- The connection with databases like *MySQL* and *MongoDB* is easy.

3.5 REACT

React is the open-source library used to build the user's interface. It is declarative and component-based and a great tool built by Facebook to avoid the cascade of updates that may happen with the growing of the applications complexity [56, 61]. By being component-based, each component controls its own state and renders itself. All the components are hierarchically combined allowing to build complete views or pages or even complex user's interface [56, 61]. The information, state information, is passed from parent-components to child-components in the form of read-only properties and in reverse direction by callbacks [56].

Furthermore, in opposition to imperative programming that declares how a certain result should be accomplished, React only declares how the views should appear in their new state. Thus, whenever there is a change on the data or state, React renders only the right components [56, 61, 62, 63]. However, when there is this change on the data, the real *Document Object Model (DOM)* isn't directly manipulated. Instead, the view looks is declared in the form of a virtual representation called virtual *DOM* technology. The following three steps resumes how the Real *DOM* is updated by the Virtual *DOM*:

1. When there is any change on the data, the *UI* is all re-rendered on the Virtual *DOM*.
2. The old Virtual *DOM* representation is compared to the new one and the differences are calculated.
3. Only the differences computed will be applied to the real *DOM*, which means the real *DOM* is updated with what has indeed changed.

This will not only allow to display the *HTML* page faster, but also efficiently since the algorithm to compute the differences in the virtual *DOM* has been so optimized [56]. Hence, besides loading new data without page refresh, the advantages of React can be summarized as [48]:

- A better performance due to a lightweight *DOM*;

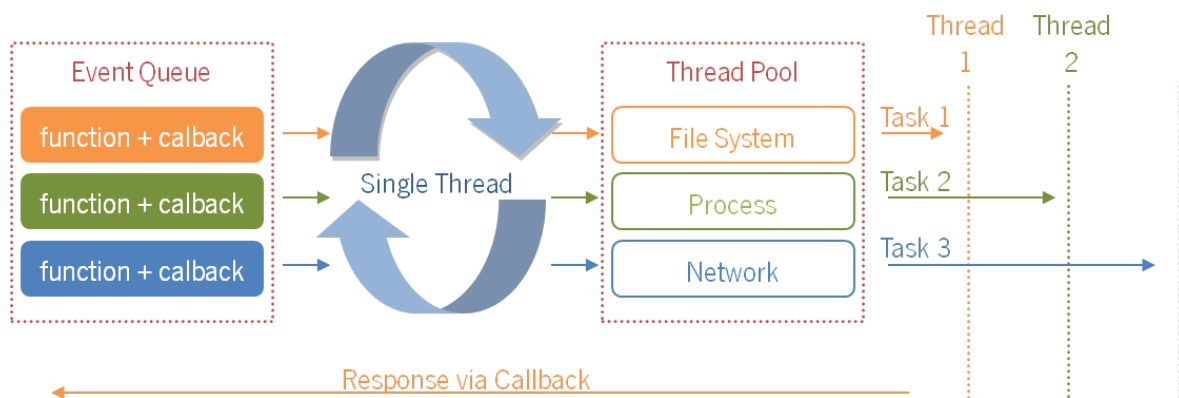
- Virtual **DOM** support;
- **JSX** support - **JSX** is a faster, safer and easier way to write and compile code;
- Easy learning curve.
- Unidirectional data flow.

3.6 NODE.JS

Node.js is the cross-platform runtime environment used to develop the web application server-side. It was based on Google's V8 **JS JavaScript** engine and it provides a set of important features for the development of web applications. Node.js also allows the installation of modules through the use of *npm* [56, 48]. It runs single thread and it is good to build event-driven networking programs. Clients are served by Node.js concurrently becoming possible to write scalable network applications [64]. After all, the capability to handle multiple users efficiently is an important aspect of the web application server and Node.js is the perfect tool to deliver real-time results [65].

Figure 2 shows how the application makes a request to the Node.js and carries on with other useful routines instead of stopping until the response arrives.

Figure 2.: Concept behind Node.js (based on [64]).



Node.js is an asynchronous and event-driven engine and the single thread on which it is based works as an infinite loop [64, 48]. It is constantly alert to the occurred events and to what callbacks need to be executed. The single thread receives async tasks from the Node.js-based app. It queues all the events like a map of all the requests. Then, one by one, the event loop removes each request from the

queue and processes it. As it is possible to observe on Figure 2, its event loop (single thread) blocks the I/O request “file system” and queues both “process” and “network” requests. This happens because API calls related to I/O are asynchronous. Then, the respective tasks are executed efficiently. After dealing with the requested task, the single thread quickly calls the right callback and steps for the next request or waits for a new request submission [64]. The single thread run by Node.js to queue all the events, instead of having one thread for each event, avoids *Central Processing Unit (CPU)* overhead [64, 65]. Thus, the data to and from the server is fast delivered and parallel computing is enabled. The pros and cons of Node.js are listed on Table 5.

Table 5.: Advantages and disadvantages of Node.js [48].

Advantages	Disadvantages
<ul style="list-style-type: none"> - To be fast; - To be open source; - To support the development of real-time applications; - To enhance the overall productivity. 	<ul style="list-style-type: none"> - The poor performance in case of CPU intensive queries and with large scale app or with relational databases; - The inconsistency issue in the Node.js API.

THE 10 MOONS – A SUPPORTING TOOL FOR FUTURE MOTHERS DURING PREGNANCY

“The 10 moons: pregnancy, childbirth and post-partum period of CMIN” was developed in cooperation with CMIN. Dr. Jorge Braga was the Obstetrician-Gynecologist behind the development of this tool for future mothers. The main idea was to implement a tool that would help women before, during and after pregnancy. Owing to the fact that it was to be used by future mothers, at first it was not intended to integrate the developed platform at the *Hospital Information System (HIS)*. CMIN requirements for the platform were:

- To be a mobile app available not only to iOS but also to other OSs if possible;
- To make available a calculator for the gestational age which would be based on his gestational age calculation method;
- To make available on the app a set of FAQs written by CMIN about the before, during and after periods of pregnancy;
- To make available on the app the BSG.

Furthermore, the resistance to adopt any mHealth app is overcome with a good UX. Since the aim of CMIN was to provide women with pregnancy literacy as well as a practical tool to record information related to their pregnancy, an informal survey was conducted among 25 pregnant women from CMIN. These women were asked the following questions:

1. Do you use any app or website to follow your pregnancy? Which ones?
2. Do you look for pregnancy related information online? If you do so, what is this information about?
3. Which are the main features you look for on a pregnancy app or website?

4. Do you find it useful to have available tips on nutrition or on a healthy lifestyle in pregnancy apps or websites?
5. Do you find it useful to have access to a pregnancy app like "The 10 moons"?
6. How do you use the pregnancy booklet [BSG](#)?

It was found that one-third of the interviewed women didn't feel the need of using a pregnancy app. The ones who used were looking for weekly information on the foetus and on the changes on mother's body. Only half of them searched online information. The ones who didn't search have given as main reasons the probable lack of quality and accuracy of the information found or how anxious they would feel after searching. Those who looked online would search for details on the foetal and mother development, cares that one must have during pregnancy, some specific doubts, nutrition, toxoplasmosis, etc. However, most of these ones who would search information reported being concerned by its validity or sometimes being left apprehensive by it. When asked which features they would like to be offered by a pregnancy app, the majority of the answers converged to foetal and mother's development, nutrition and FAQs. Other answers referred to information on sexual and physical activity, symptoms, cares, medical appointments, gestational diabetes, illustrative pictures and videos and the possibility of saving documents. Based on all the information collected, other extra features have been added in order to enhance the [UX](#). These features are:

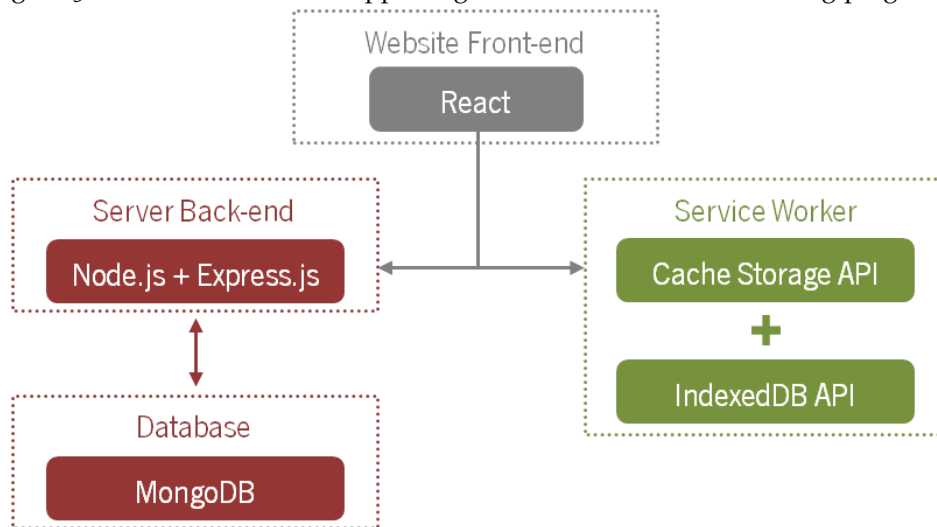
- The possibility of saving documents such as ultrasounds and analysis;
- A calendar where women might record appointments;
- Information on foetal development as well as changes occurring on pregnant women's body weekly provided;
- Other pregnancy health information which is provided based on their gestational age or health conditions;
- Other tracking tools besides weight, blood pressure and foetal movements monitoring that already come with the [BSG](#).

The work presented hereby focuses on two main areas: the monitoring of other pregnancy-related data as well as the providing pregnancy-related and health information. Therefore, throughout this chapter, the global system architecture is presented and followed by the description of the focusing areas components.

4.1 SYSTEM ARCHITECTURE

The platform architecture might be divided into two distinct parts. The components that are common to a classic web app – the website front-end, the server and the database – and the component that converts the web app into a PWA – the SW. Figure 3 represents the system architecture of the developed PWA.

Figure 3.: Architecture of the supporting tool for future mothers during pregnancy.



Firstly, it was important to guarantee that the interface would be suitable for all the screen sizes and devices, that is to develop a responsive UI, whether it is a classic web app or a PWA. The module React-Bootstrap, which binds the most popular front-end framework with React, was used to achieve this. Then, the app was built as a classic web app. The front-end would request data from the server. The server, Node.js, would analyse the request, but it was Express.js that would ask the data to the database through REST architecture. Basically, the Express.js matches the request with the present routes and executes the correspondent handler function. Each route is identified by an HTTP method and the URI. The handler function leads with the request object and the response object. The request object that comes from the client is properly analysed to ask for the right data from the database. The proper response is generated by the handler function, based on the response object, and sent to the client.

Lastly, the implemented web app was converted on a PWA with the introduction of the SW in the system architecture. It was also needed to add an app manifest as the one previously referred to on the State of the Art. The SW was combined with two

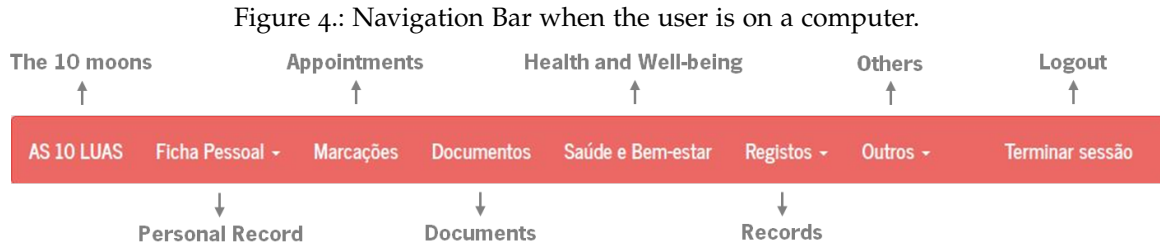
client-side storage APIs: the Cache Storage API and the IndexedDB API. This merge of technologies leads to a higher performance of the apps as well as to the possibility of having them working offline. The SW will intercept the network requests and handle them. Therefore, the use of the SW has the following advantages [17, 66, 67, 68]:

- **The improvement of the platform performance.** The Cache Storage API is a persistent content storage and allows PWAs to precache resources. These resources are parts of the web app – the assets cached on the project were the CSS and the JS files – and the next time the user opens the app the content will be loaded instantly.
- **The availability of the app even when offline.** The Cache Storage API is also independent from the browser HTTP cache and, consequently, network independent. When the user is offline, the data stored at the Cache Storage API is served. Moreover, the IndexedDB API is a large-scale NoSQL storage system which enables to store the data in the users' browsers and also serve it when offline. IndexedDB API will hold the data that need to become persistent. Thus, the static data that will build some pages of the project, like the information on foetal development, was stored on the IndexedDB API. This information is previously requested by the SW to the server and only then saved on the IndexedDB Object Store.
- **The advanced features that become available.** These features, whose starting point is provided by the SW, make the PWA behave more likely a native app. Notifications API, Push API, Background Sync API and Channel Messaging API are some examples of these features. For instance, the Notifications API allows displaying and interacting with notifications by means of the OS native notification system. Furthermore, the users may postpone actions until they are online due to the Background Sync API. Likewise, this API also enables the server to push periodic updates in order to update the app when there is connectivity.

4.2 PLATFORM COMPONENTS DESCRIPTION

As stated before, the developed platform can be divided into three main parts: the FAQs, legislation, appointments and saved documents; the pregnancy booklet BSG; and monitoring pregnancy and information on healthy lifestyle. The focus of this work, and whose components will be described, was on the third subject and aims

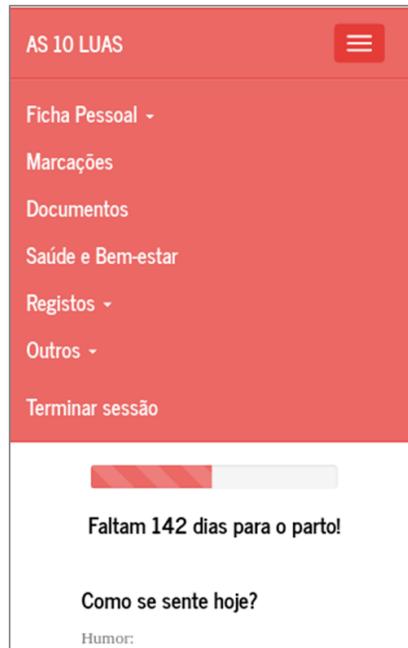
to enhance the [UX](#). To have access to this part of the platform and to its features, pregnant women will need to be identified by their e-mail and password at the login interface. Moreover, after the user's login, all the pages have the same Navigation Bar presented on [Figure 4](#) that will allow the user to browse through the [PWA](#).



"The 10 moons" will link to the User's Home, the "Personal Record" to the personal data and health record, "Appointments" to medical appointments that the user might have recorded, "Documents" to the documents that the user might have uploaded, "Health and Well-being" to the Health and Well-being Home from where the user can have access to Foetal Development, Advice for Future Moms and the Pregnancy Log, "Records" to weight, blood pressure, fundal height, foetal movements and blood sugar (in case of having Diabetes or Gestational Diabetes), and "Others" to birth calculator, FAQs and legislation. The Navigation Bar provided to the users when accessing the platform via mobile can be seen on [Figure 5](#).

This part of the platform can be divided into six main modules, which will be detailed on the following sections. These modules are the User's Home, the Health and Well-being Home, Foetal Development, Advice for Future Moms, the Pregnancy Log and the Gestational Diabetes Record. All these components have a responsive interface. Only the necessary figures to understand the platform features will be presented on this chapter. Further figures illustrating particular platform features or the responsive interface used on mobile can be found on [Chapter A](#).

Figure 5.: Navigation Bar when the user is on a smartphone.



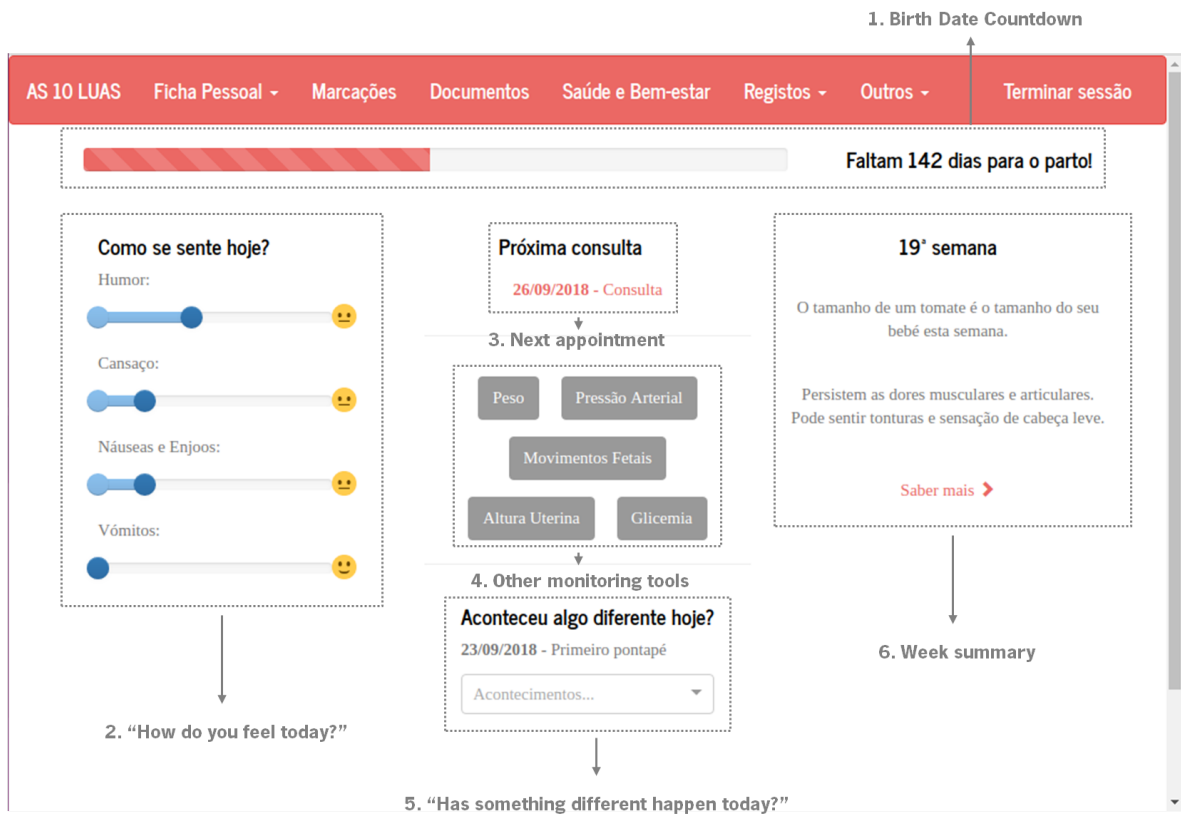
4.2.1 User's Home Module

The User's Home Module is formed by the dashboard. The user's interaction with the platform, after the login has been made, starts with this dashboard. This component is responsible for displaying the most important and needed data as well as a quick access to useful features. Hence, the User's Home Module is built out of:

1. **The birth date countdown:** This feature is based on the user's gestational age and aims to raise awareness to the remaining pregnancy days. Bachiri et al. in their 2016 study [31] assessed which features could be used on pregnancy apps and their importance. Among them, there was the birth date countdown. To provide this information to future mothers would help them keep track of their pregnancy. Besides, it was chosen to use a progress bar as the visual structure to represent the birth date countdown because, as stated in [69], timelines such as the one implemented are an effective way to present information.
2. **The "How do you feel today?":** Women develop new symptoms during pregnancy which might be widely accepted as normal, like nausea, vomiting, headaches or tiredness, among others. Although being normal, these symptoms might also be caused by a disease. Monitoring these symptoms might be beneficial to avoid complications [31, 70].

3. **The next appointment:** Here is presented the date and the name of the next recorded appointment. It is also an option to redirect straight to the "Appointments" page which was developed by another colleague.
4. **The other monitoring tools:** Due to the importance of tracking these parameters, this section of the dashboard only aims to provide the user a quicker and more intuitive way to record their weight, blood pressure, foetal movements, fundal height and blood sugar.
5. **The "Has something different happen today?":** This is another monitoring tool where the future mother may select small events or occurrences: vitamins intake, iron intake, folic acid intake, finding out baby's sex, first movement, first kick, first contraction, not being able to see her feet, gestational diabetes diagnosis and the birth of the baby.
6. **The week summary:** By providing information on the changes occurring on mother's body, on the evolution of the foetus development and size, on health habits and problems or risk of each stage of pregnancy, pregnant women become more aware of their pregnancy [31]. Therefore, "the week summary" is a summary of the changes on mother's body as well as the size of the baby for that week. At the bottom, there is a "Know more" button that links to the Health and Well-being Home Module.

Figure 6.: Interface of the User’s Home Module when the user is online and on a computer.



Thus, an overall view of future mom’s pregnancy as well as a faster access to features that might be important for her are provided by the User’s Home Module. Figure 6 shows the dashboard interface on a computer with its components.

4.2.2 Health and Well-being Home Module

Pregnancy apps and EMR are a great place to encourage special health habits as preventive measures [31]. Moreover, a healthy pregnancy, which is a pregnancy with a healthy and safe diet, regular and appropriated physical activity and the avoidance of harmful agents, reduces the risk of pregnancy complications and leads to a healthy birth [71, 72]. For instance, exposing the foetus to harmful agents like tobacco may lead to a preterm birth and augment the risk of Sudden Infant Death Syndrome, which is the main cause of an infant’s death aged 1 month to 1 year old [73, 74, 75]. When pregnant women smoke, one of the toxic chemicals that passes through the placenta is the nicotine. The amount of oxygen and nutrients that reach

the foetus become less and it permanently harms the brain and lungs of the foetus [73, 74].

Another harmful agent during pregnancy is alcohol consumption. Its consumption may cause birth defects, such as permanent physical, intellectual, behavioural and learning disabilities. Drinking large amounts of alcohol during pregnancy increases the chances of developing the most severe disorder: Foetal Alcohol Syndrome [74]. A baby with this disease will have a smaller head, inferior growth, co-ordination and learning problems, autism-like behaviour or attention deficit hyperactivity disorder, and organ (heart, liver, hearing, sight, etc.) problems [76].

Furthermore, Bachiri et al. in their 2016 study [31] also suggest apps to give additional support on the serology subject. The toxoplasmosis, the listeriosis and the hygiene care needed to avoid these diseases are introduced on this module. Toxoplasmosis is caused by the ingestion of contaminated food by the parasite – it can be found in cat faeces or in undercooked meat. This infection can be deadly or cause birth defects. The risk for the foetus is related to the gestational age. It decreases with the gestational age, but the chance of transmission from the mother to the foetus increases as the pregnancy advances [77]. Listeriosis, caused by a bacterium usually existent on the water or soil, can also be deadly and found on contaminated food [78].

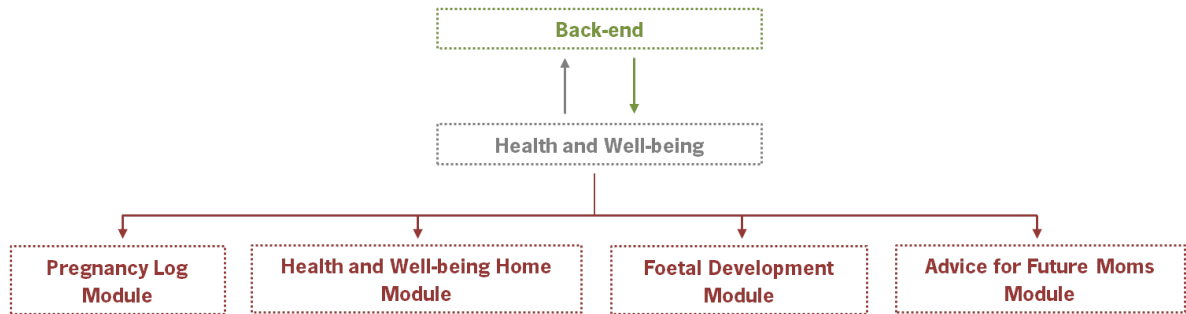
For these reasons and with the intent of promoting a healthy pregnancy, the Health and Well-being Home Module, whose interface is shown in Figure 7, aims to introduce and encourage healthy habits through 10 general and small tips about nutrition, physical activity, hygiene care, harmful agents, tracking pregnancy, among others. This module is based on the facts referred to above.

Figure 7.: Top of the interface of the Health and Well-being Home Module when the user is online and on a computer.



The Health and Well-being Home Module, like the following Pregnancy Log Module, Foetal Development Module and Advice for Future Moms Module, is a child-component of the "Health and Well-being". The parent-component – "Health and Well-being" – is composed by the four icons on the right side of the interface (see Figure 7). By taking full advantage of React, each icon links to the Pregnancy Log, the Foetal Development, the Advice for Future Moms and the Health and Well-being Home respectively, from top to bottom. Through a change of state caused by a click on each icon, the parent-component defines which child-component is presented to the user. Moreover, the parent-component can, and does, pass information to their child-components as referred on Section 3.5 about React. An example of this interaction is the one that will be described between the "Health and Well-being" and its child-components.

Figure 8.: Health and Well-being parent-component and child-components and how they interact with each other.



The "Health and Well-being" asks the back-end by the gestational week by passing the ID that identifies the user. The Express.js+Node.js asks the database for the data saved about that user. Then, the data of interest is analysed and the gestational week is sent to the parent-component at the front-end. Although the Health and Well-being Home Module doesn't take advantage of this information, the parent-component passes the gestational week, which has become state information on that component, to their child-components via read-only properties. Figure 8 illustrates this situation. Despite the fact that Figure 8 only considers the interaction of the parent-component with the back-end, it must be noticed that all the child-components may also request that to the back-end.

4.2.3 Pregnancy Log Module

Bachiri et al. in their 2016 study [31] explained the importance and the positive effect of a diary during pregnancy. They see the diary as a place where women can record their perceptions of events and feelings to later communicate with the doctor. They see diaries as a mechanism to help the detection of potential problems.

The diary here implemented aims to allow the users record whatever they want, but also to encourage the record of food intake and physical activity. To a healthy pregnant woman it might not make difference to have a place where they can record this type of information. However, for women who start their pregnancy underweight or overweight or have been diagnosed with a medical condition such as diabetes, this type of feature might be beneficial to them.

The interface of this module can be seen on Figure 9. It has four types of record: "Meals", "Physical Activity", "Notes", "Nausea and Sickness". Any record must be done by clicking on the New Record button as well as any record selected is deleted

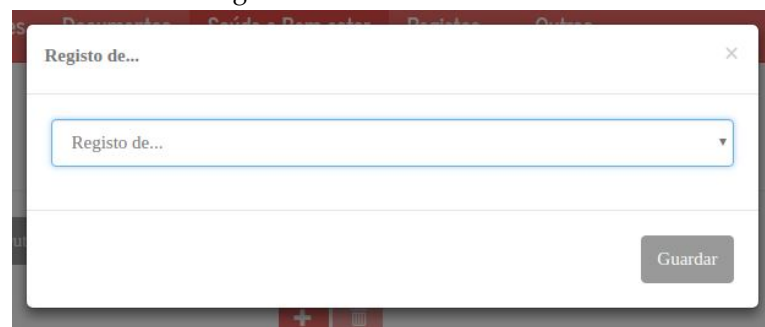
by the Delete Record button. The user can navigate between older records through the bar that is on top of the record area.

Figure 9.: Pregnancy Log Module interface.



After clicking on the New Record button, the user has access to a modal where she can choose the type of record. This modal is represented on Figure 10.

Figure 10.: New Record modal.



When the user chooses to record information about the meals and food intake, the modal aspect will be the one of Figure 11. There, the user can record what she has eaten, the time of the meal and/or the type of meal (snack, breakfast, lunch, dinner or supper). The time and/or type of meal are important to later present more organised information to the user. She must set the time or type of meal to be able to save that record.

Figure 11.: Record of a new meal.

If the user chooses to record a physical activity, then the modal let her record a description of the physical activity, the starting time and the duration, as it can be seen on Figure 12.

Figure 12.: Record of a physical activity.

The aim of recording nausea and vomiting is to give the pregnant woman the opportunity of perceiving at what time of the day she feels sicker. This way, she can take precautions on the following days to avoid these feelings since they have a huge impact of the pregnant women's quality of life. Figure 13 shows the modal when the pregnant women want to record vomiting. A similar modal is shown in case they intend to record nausea. They must also record the hours or the time of the day. This is important to make the records more organised and to allow the users to understand if the nausea and sickness are related to a certain time of the day or a certain meal.

Figure 13.: Record of sickness.

Registo de...

Vómitos

Diga-nos quando ou em que altura do dia.

At what time? → hh:mm ☰

→ At what time of the day? Caso prefira dizer-nos a altura do dia...

Guardar

At last, Figure 14 shows the aspect of the modal when the user wants to take notes. These notes can be about anything that may have happened during the pregnancy and which she might want discuss with her doctor at the next appointment.

Figure 14.: Record of notes.

Registo de...

Pequenas notas e resumo do dia

Placeholder for notes → Aqui pode acrescentar notas sobre o dia de hoje

Guardar

4.2.4 Foetal Development Module

One of the most common information provided to pregnant women on pregnancy apps is about the foetal development. According to the performed survey, which is referred to at the beginning of this chapter, and to the background presented on Chapter 1, foetal development is one of the most searched topics. Knowing how the baby is evolving, mainly during the first part of the pregnancy when the foetal movements cannot be felt, would emphasize the connection between the future mother and the baby. Additionally, future mothers would feel more confident about their baby and their baby's health knowing this information [79].

Hence, this module doesn't introduce anything new, but something needed to pro-

vide the users with a good **UX**. When the user accesses to The Foetal Development Module, it is provided the information of the current gestational week. However, users may navigate through the gestational weeks, back and forward on the Bootstrap Carousel, to check what changes have passed and which are to come. This module uses the gestational week coming from its parent-component to present the right slide of the Carousel to the user. The information that builds the Carousel is stored on the database.

Figure 15.: Interface of the Foetal Development Module when the user is online and on a computer.



4.2.5 Advice for Future Moms Module

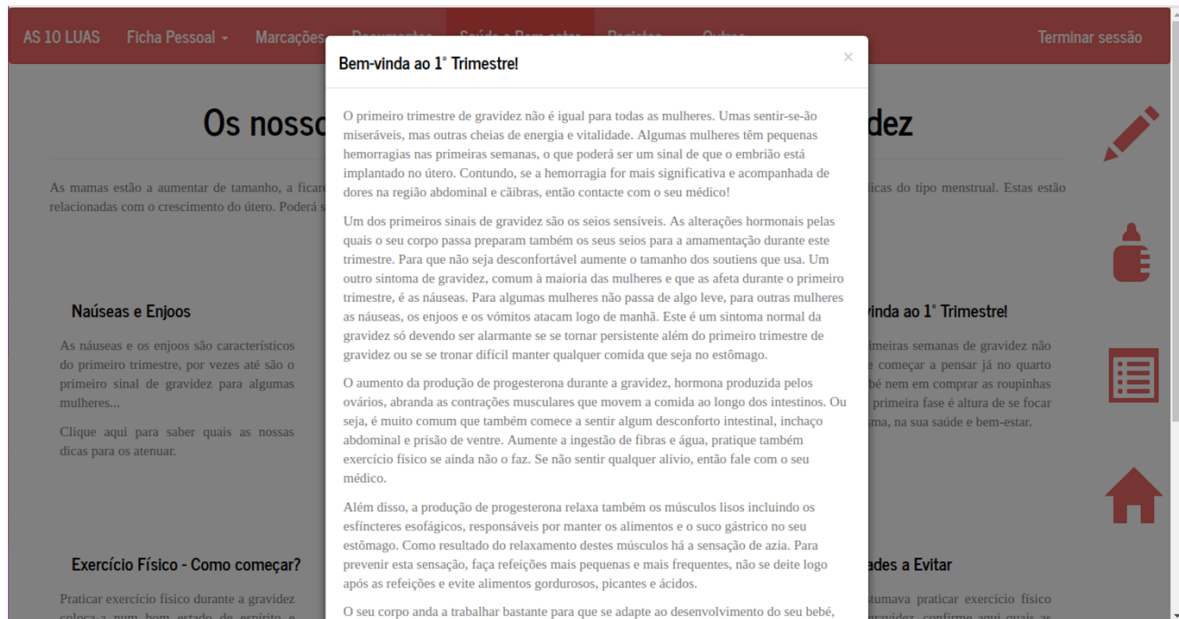
One of the first things that was referred to at the very beginning of this document was the amount of information searched by women during pregnancy. The development of this module aimed to provide women with viable information and controlled information. Besides, another suggestion of Bachiri et al. in [31] is that the information supplied by mobile apps would have the mother's health history data as basis. They also mention that having an informational part at the apps would help pregnant women to be aware of the risks related to each stage of pregnancy.

Figure 16.: Advice for Future Moms Module interface.



The Advice for Future Moms Module has three main areas and they can be seen on Figure 16. The first one is the four buttons at the right side of the interface which have already been explained in Section 4.2.2. They are linked to all the other interfaces related to Health and Well-being, allowing the user to navigate between them. The second area of this module is the "Changes on mother's body". General information of the changes occurring on that week of pregnancy on mother's body is presented there and is stored on the database. This component uses the data on the gestational week passed by the parent-component and asks the back-end for the changes on mother's body for that week. Lastly, the third part of the Advice for Future Moms Module, and probably the most interesting one of this module, is the "Advice". This advice is given through articles (see Figure 17) and according to the collected health data. Each trimester has a "Welcome to first/second/third trimester!" article that only aims to inform the pregnant women about all the changes and what they can expect for that trimester. After this, the advice given on this part of the Advice for Future Moms Module will be explored. Each article can be seen on Chapter A.

Figure 17.: Example of an article – “Welcome to the first trimester!” – of the Advice for Future Moms Module interface.



Nutrition during pregnancy: Pregnant women are advised on nutrition with three articles: “What to eat?” (Figure 29), “Essential nutrients” (Figure 30) and “Essential vitamins” (Figure 31). The DGS in [80] warn of the importance of healthy nutrition during pregnancy. They inform that a healthy pregnant woman during pregnancy has better chances of a easier delivery and also leads to healthy growth of their baby. Additionally, the lack of some nutrients or vitamins during pregnancy may increase the risk of the baby developing malformations. For instance, the intake of folic acid, a vitamin of the B complex also known as B9, has a great role on preventing malformations on the baby’s neural tube. This tube is the embryonic structure that later will be the central nervous system and form the brain and the spinal cord [80].

Iron is another of these nutrients that cannot be missing during pregnancy. During this period, the blood volume on the mother’s body increases. Iron is essential for preventing iron deficiency anaemia. The lack of this mineral increases the risk of the baby born underweight, premature or even of perinatal mortality (baby’s death between the 22nd gestational week and the first week after being born) and of deficiency on the neurological system [80, 6]. Likewise, there are other nutrients and vitamins whose deficiency have an impact on the baby’s development and sometimes on the mother’s well-being. For that reason, the three articles advising on nutrition are shown to all pregnant women during all the gestational period.

These intend to inform about the important nutrients and vitamins, where they can be found, how to eat correctly and what food should be avoided.

Nausea and Sickness: 70% of pregnant women feel these symptoms. Nausea and sickness are common during the first trimester of pregnancy as a result of the hormonal changes their body is going through [80]. Usually they start between the 4th and the 7th gestational week until the 12th gestational week. However, some women might feel some nausea up till the 20th gestational week. They are normally felt with higher intensity in the morning and aren't associated with a poor prognosis. Nevertheless, the presence of these symptoms influence the pregnant woman and her family's quality of life (depression, depressed mood or missing work). On the worst cases of nausea and sickness, denominated hyperemesis gravidarum, pregnant women feel continued vomiting, dehydration and weight loss [81]. On this topic, two articles can be displayed. One (see Figure 32) is only provided during the first trimester. It has practical tips to relieve the user of these symptoms. If on "How do you feel today?" of the User's Home Module described on Section 4.2.1 nausea and sickness and/or vomits are recorded during the second trimester, then a second article (see Figure 33) is provided to the user giving her the same tips as the ones of the first trimester, warning her that it is important to gain weight and advising her to talk to her doctor.

Dizziness: Dizziness during pregnancy is perfectly normal and more common during the first trimester. In the same way as nausea and sickness, dizziness also happens due to the change of hormones. These hormones aim to help the blood flow to the baby, yet the blood flow to the brain is reduced [82]. There is nothing wrong with that, a little dizziness doesn't harm the baby nor the mother. However, it may be dangerous if it results in falls or faints. On that account, during the first trimester pregnant women are provided with a set of tips to reduce dizziness and on how they should behave when feeling dizzy to prevent falls or faints (see Figure 34).

Gestational Diabetes: Gestational diabetes is a condition that might happen during pregnancy and disappear after childbirth on women who didn't have diabetes mellitus previously. This diagnosis is detailed on Section 4.2.6. Based on [83], the risk factors that may lead to the gestational diabetes diagnosis can be summed up to the age, the presence of diabetes mellitus on the family health history and to being overweight. Despite the age and the family health history could not be controlled by the pregnant women, a controlled weight and a balanced diet can be reached.

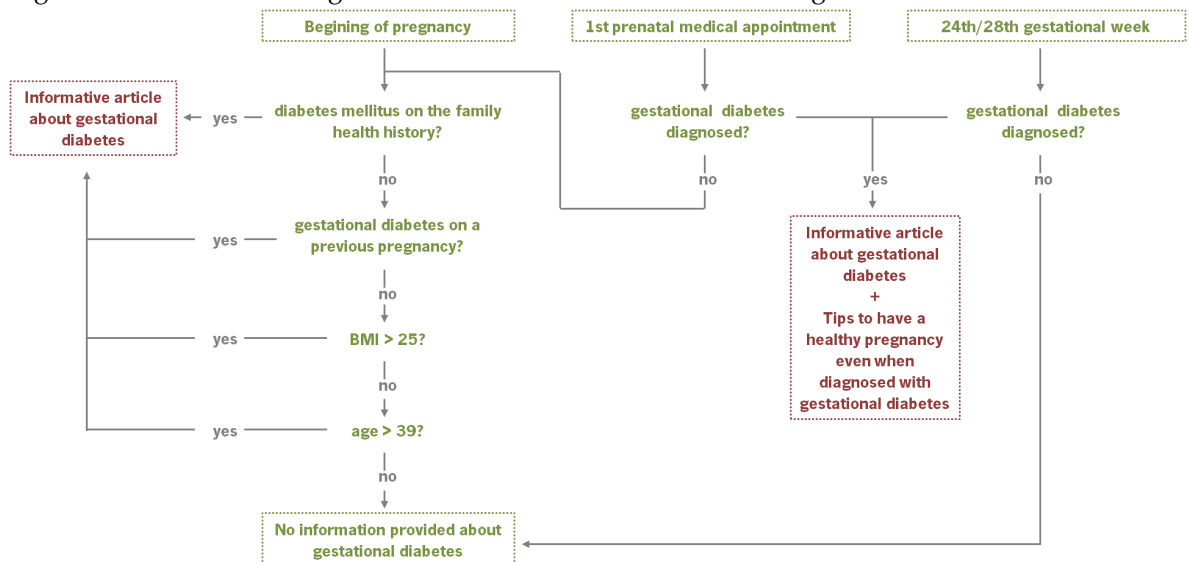
The data collected from the user, on the **BSG** part of this platform, is analysed. If a pregnant woman has at least one of these conditions:

- diabetes mellitus on the family health history;
- gestational diabetes on a previous pregnancy;
- **BMI** above 25 (the inferior limit for being considered overweight);
- above 39 years old;

then she is at risk of having gestational diabetes. Thus, it will be presented to these women an article (see Figure 35) about gestational diabetes in order to inform them about the condition and how to avoid it and to alert them of the possible risks. The diagnosis of gestational diabetes only can happen until the 28th gestational week (see Section 4.2.6). If the record of gestational diabetes isn't made until that week, then the article will no longer be shown even if the woman has the four conditions referred before.

Furthermore, when the user records being diagnosed with gestational diabetes in the "Has something different happen today?" of the User's Home Module (see Section 4.2.1), to the first mentioned article is added another one (see Figure 36). This last one gives tips to help her keeping the health condition diagnosed controlled. All these decisions can be seen on Figure 18.

Figure 18.: Schema showing how the informative articles related to gestational diabetes are chosen.



Underweight: Starting the pregnancy being underweight might be a risk for the well-being of the baby. Women who start the pregnancy with a normal BMI must weight more 11,5-16kg at the end of the pregnancy. However, those with a low BMI must gain more 12,5-18kg. If the mother starts the pregnancy underweight and doesn't obtain the expected weight, there might be a delay on the intrauterine growth of the baby and the risk of perinatal mortality (baby's death between the 22nd gestational week and the first week after being born) increases [80]. Therefore, an article on starting the pregnancy being underweight is shown to those women who have a BMI under 18 (see Figure 37). This aims to warn them about the risks they are putting their baby through and how they can change that.

Physical Activity: Physical activity has benefits at any period of life and pregnancy is no exception. The WHO recommended to exercise regularly during all the pregnancy. This would help pregnant women to avoid backaches and pelvic pain [84]. Moreover, exercise during pregnancy would help pregnant women to avoid gain excessive gestational weight and to reduce the risk of conditions as gestational diabetes, pre-eclampsia, preterm birth, varicose veins, among others. Besides, physical activity has also psychological benefits, such as reduced fatigue, stress, anxiety and depression [85].

Apart from that, pregnant women have a greater risk of injury and adaptations of the exercise are needed. For example, activities that have higher risk of falls or trauma or that are made in altitude or depth must be avoided during pregnancy. Aside from these activities that must be avoided, with the pregnancy evolution, there are also more cares needed while exercising. An example of that is the supine position (lying on one's back), which is dangerous after the first trimester or after the 16th gestational week, and that may be done on activities like yoga. The uterus grows along the pregnancy and, after the first trimester, its weight may cause the collapse of the abdominal aorta and obstruct the venous return [85].

During all the pregnancy, pregnant women have access to three articles on physical activity. One of them (see Figure 38) aims to encourage those women who didn't use to exercise before pregnancy and to remind women who used to do it, as well, of the precautions. Another article (see Figure 39) is shown to women to make them aware of the activities they must avoid during pregnancy. Lastly, the third one informs pregnant women of which physical activities are safe and indicated. Since the cares while exercising increase with the gestational age, the advice on this last article is updated with the new cares and the safest physical activities for each trimester (see Figure 40, Figure 41 and Figure 42).

Pre-eclampsia: Hypertensive disorders during pregnancy are a major cause of severe morbidity, long-term disability and death of both mothers and babies. Pre-eclampsia and eclampsia are the two most dangerous hypertensive disorders. The diagnosis of pre-eclampsia isn't certain yet, but persistent hypertension and occurrence of substantial proteinuria are thought to be its symptoms. On the other hand, eclampsia is generalized seizures followed by pre-eclampsia criteria. Usually, pre-eclampsia may be diagnosed on the second half of pregnancy. It is classified as mild or severe and maternal deaths happen on the most severe cases. Nevertheless, it may evolve from mild to severe quickly, unexpectedly and sometimes it can be fulminant [86].

The prevention of pre-eclampsia is still a subject of research and the only definitive treatment is the termination of pregnancy or the delivery. However, some women experience transient aggravation of pre-eclampsia in the post-partum period. If pre-eclampsia is not treated and the pregnancy is delayed, pre-eclampsia advances to placental insufficiency and maternal organ dysfunction, which are related with the increasing of the maternal and perinatal mortality risk. Possibly, it might even progress to eclampsia or HELLP syndrome (haemolysis, elevated liver enzymes and low platelet count) [86].

According to WHO in their 2011 recommendations for the prevention and treatment of pre-eclampsia and eclampsia in [86], the risk factors for pre-eclampsia are:

- Obesity;
- Chronic hypertension;
- Diabetes;
- Nulliparity (a woman who has never given birth);
- Adolescent pregnancy;
- Conditions leading to hyperplacentation and large placentas, like twin pregnancy.

With the exception of the nulliparity, which is a very general condition, all the pregnant women who might have at least one of the previous listed conditions will be provided with an informative article on pre-eclampsia and the characteristic symptoms of this medical condition (see Figure 43). Pregnant women older than 39 years old or with pre-eclampsia on the family health history or even on older pregnancies are also provided with the same advice.

4.2.6 Gestational Diabetes Record Module

It is estimated that one on each 20 pregnant women might have been diagnosed with gestational diabetes. This type of diabetes appear during pregnancy on women who hadn't had diabetes before and tend to disappear after birth [83]. The diagnosis of gestational diabetes can be made in two different times. On the first prenatal medical appointment, all the pregnant women are put through a plasmatic glucose exam while (8h to 12h) fasting. If a pregnant woman has developed gestational diabetes, she will be diagnosed with this medical exam. Otherwise, she will have to be reevaluated between the 24th and the 28th gestational week. The reevaluation is made with the glucose tolerance test [87].

Although less often, women might also be diagnosed, on the first prenatal medical appointment, with diabetes mellitus during pregnancy. Usually, this type of diagnosis reflects the existence of diabetes before pregnancy. Women who have been diagnosed with diabetes have higher glycaemic values than the ones with gestational diabetes. Besides, having diabetes during pregnancy is more dangerous and pregnant women need more surveillance than the ones with gestational diabetes [87].

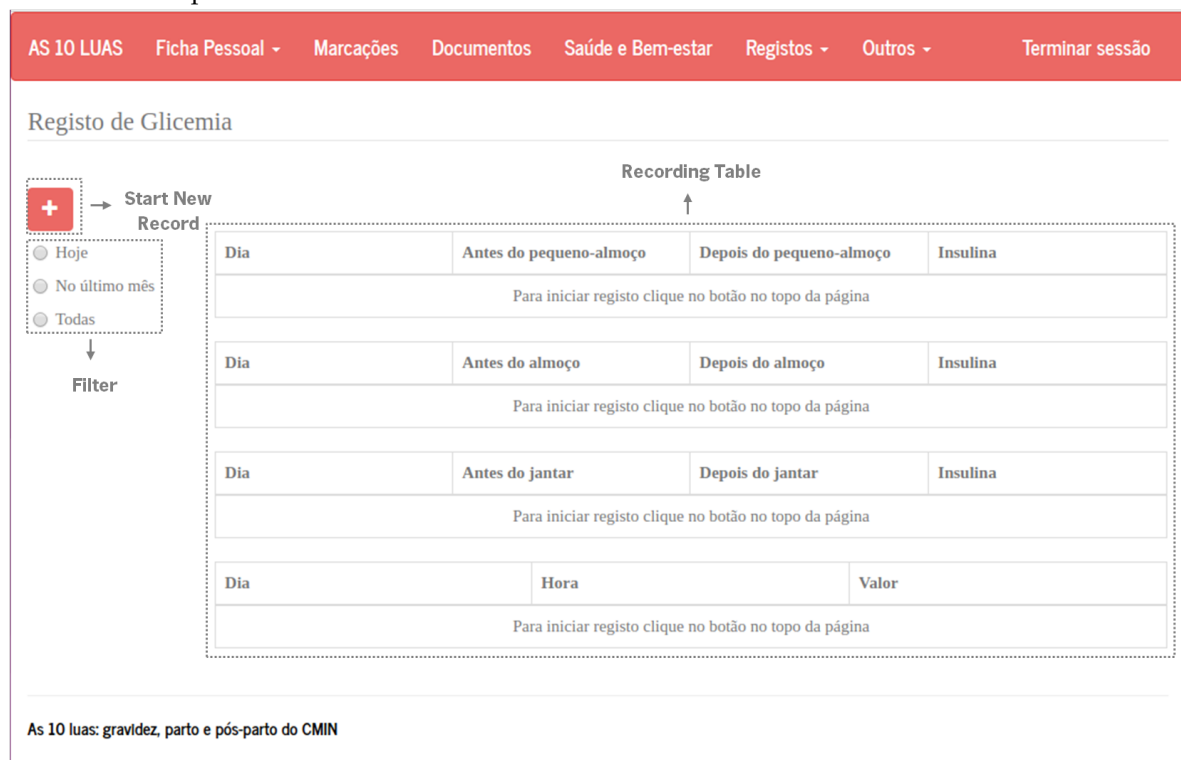
Women with gestational diabetes have more chances of having to do a C-section. The main reason behind this is the foetus size, since their babies tend to be born with extra weight – macrosomic foetus. Gestational diabetes increases the hypertension risk, which may lead to a higher risk of pre-eclampsia (see Section 4.2.5). Although foetal malformations aren't caused by gestational diabetes, women with uncontrolled diabetes mellitus at the beginning of their pregnancy have a higher chance of giving birth to a baby with malformations. The diagnosis of pre-eclampsia may also occur on women with diabetes mellitus [83].

There are two types of therapy: nutritional therapy (non pharmacological) and the pharmacological therapy. The nutritional therapy is only based on a nutritional plan and on physical exercise. The pharmacological therapy, in case of gestational diabetes, is started when the glycaemic values aimed aren't being achieved after two weeks of nutritional therapy. During this second type of therapy, three medications might be administrated: metformin, glibenclamide or insulin. Both of them – nutritional and pharmacological therapy – involve the monitoring of capillary glycaemia values. The glycaemic vigilance followed by women through a nutritional therapy must have 4 capillary glycaemia measurements: one fasting and the others 1 hour after the three main meals (breakfast, lunch and dinner). When the the pharmacological therapy is followed, besides the 4 capillary glycaemia measurements

referred, the other measurements that women also have to perform are related to the therapy schema and to the pharmacological administration [87].

The DGS in their directive number 7 on gestational diabetes diagnosis in [88] states that the glycaemia control during pregnancy is proven to decrease the maternal complications and the perinatal mortality and morbidity. Gestational Diabetes Record Module was implemented to help future mothers, who have been diagnosed with gestational diabetes, diabetes mellitus or even those already having diabetes mellitus before becoming pregnant, keeping track of their glycaemic values and/or insulin intake (in case of following pharmacological therapy).

Figure 19.: Interface of the Gestational Diabetes Record Module when the user is online and on a computer.



On Figure 19 the interface of the Gestational Diabetes Record Module is shown when the user hasn't made her first record of the day yet. This interface is intuitive and has three main components: the Start New Record, the Filter and the Recording Table. If the user is following a pharmacological therapy, here it is only considered the use of insulin for being the most common.

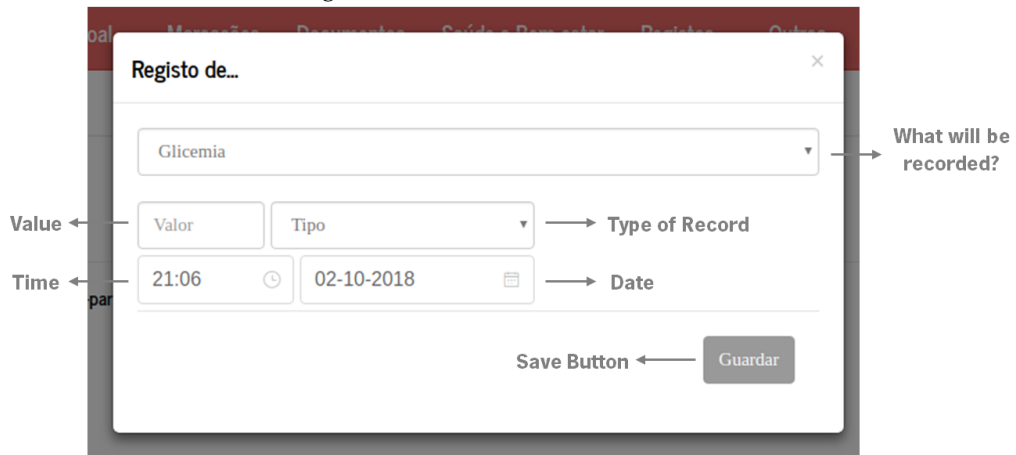
Start New Record

When the user wants to introduce the first value, she must click on the Start New Record button and the Figure 20 modal will become visible. By default the modal let the user record the glycaemia values. In order to save them, the user must fill the four fields: value, type, time, date.

The type of record is used to determine if the measurement was made: fasting, after breakfast, before lunch, after lunch, before dinner, after dinner, before bedtime or if that is an extra measurement. This meets not only the nutritional therapy but also the pharmacological therapy. As it was previously explained, when the nutritional therapy is followed, pregnant women must do 4 capillary measurements: one while fasting and the other three after the three main meals. In case insulin is the medicine used on pharmacological therapy, then a usual therapy schema is to perform measurements before the three main meals apart from the same 4 capillary glycaemia measurements, also made on nutritional therapy. Except when the recorded value is an extra measurement, the time has no importance. Therefore, the time and date are intended to allow the user to record past values or extra measurements.

If the user selects that what will be recorded is insulin, then all the parameters needed to save the record are the same, except the type of record. The type of insulin administration schema are related to each person's need. It may vary from one to several daily administrations and these are associated with the main meals. The therapy schema for metformin and glibenclamide is similar. The frequency of administration of both medicines range from one to three times per day and they are also associated with the main meals: metformin should be taken during or after meals and glibenclamide before. Thus, in case the user selects to record insulin, there are only three types possible: breakfast, lunch or dinner. As this modal was built, it might be used by those who follow a nutritional therapy as well as by the others who have to follow a pharmacological one.

Figure 20.: Start New Record modal.



Recording Table

On Figure 19 the existence of four tables can be noticed. To keep the records more clear and organised, it was chosen to group them in breakfast (fasting and after breakfast), (before and after) lunch, (before and after) dinner and extra. The tables were built using the react-bootstrap-table2 module. If the user introduces her glycaemic value after breakfast of 120 mg/dl and the extra value obtained at 11:30 a.m. of 100mg/dl, the Recording Table aspect will be the one showed by Figure 21.

Figure 21.: Recording Table.

Dia	Antes do pequeno-almoço	Depois do pequeno-almoço	Insulina
03-10-2018		120	

Dia	Antes do almoço	Depois do almoço	Insulina
Para iniciar registo clique no botão no topo da página			

Dia	Antes do jantar	Depois do jantar	Insulina
Para iniciar registo clique no botão no topo da página			

Dia	Hora	Valor
03-10-2018	11:30	100

With the exception of the date, all the values may be easily edited, deleted or added. Figure 21 shows how to edit a value with a simple click on the cell of interest.

Figure 22.: Editing glycaemic value on Recording Table.

Dia	Antes do pequeno-almoço	Depois do pequeno-almoço	Insulina
03-10-2018		<input data-bbox="850 555 1088 604" type="text" value="120"/>	

DISCUSSION

The work developed led to the implementation of a platform to support future mothers during pregnancy. Through this fifth chapter, it is made the discussion of the work presented, from the selection of the type of mobile development and technologies to the final appearance and features of the implemented platform. Despite not being an extensive chapter, it will be divided into two sections to make the reading easier. The first section, Mobile Development and Technologies, discusses the choice of developing a [PWA](#) and the choice of the [MERN](#) Stack. The second section, Supporting Tool, discusses the choices made on the front-end development.

5.1 MOBILE DEVELOPMENT AND TECHNOLOGIES

At the beginning, the main aim was to develop a cross-platform mobile app as well as a website. Developing a web app was out of question from the beginning. Although it would be quicker to develop it allowing us more time to work on its design and content, a web app needs the web mobile browser to run leading to a lack of app appearance and to a need of internet connection. Choosing to develop a native app would be the ideal to give the user an app with the best interface and all the benefits of the look and feel of the [OS](#). However, being the development of a native app a lot harder than a web app, being needed to develop different versions for the different [OS](#) and being our experience on mobile development none, it would be impractical and impossible to have implemented a platform so complete as the one here presented. Developing a hybrid app and a website, separately, was the first choice and, when compared to the previous two, was the one that would lead to a more efficient development of a mobile app and a website.

Nevertheless, after a little more research the [PWA](#) methodology was found. This recent technology would let us take advantage of the developed website, which would work as a web app, and also make it possible to be used like a mobile app with less time and effort than any of the previous options. In fact, after having the

web app made, it was quickly converted to a **PWA**: a **SW** was created as well as a web app manifest added. Aside from all the advantages for the platform performance and **UX**, the main value added to this project by implementing a **PWA** was the development of a consistent and meaningful platform from scratch and with no experience in the limited time available.

Afterwards, the choice of technologies came. The implementation of a **PWA** starts by developing a web app, which in turn is implemented through web technologies – **JS**, **HTML** and **CSS**. Our first thought was to reduce the learning time by trying to use a stack that was intuitive and would use the same programming language: the **JS**. The old-school **LAMP** Stack would not fulfil both of these conditions. It is difficult to learn and lacks simplicity. The choice was between the **MEAN** and the **MERN** Stacks. Both of them were based on the programming language **JS** and the major difference was related to the front-end development: the **MEAN** Stack uses the framework AngularJS and the **MERN** Stack uses the **JS** library React. Besides, the **MEAN** Stack was the first one to appear and, thus, the **MERN** Stack has emerged to amend an existent problem on the first stack: the cascading of updates that would come with the growing complexity of the app.

The differences between the **MEAN** and the **MERN** Stacks have been analysed. The **MEAN** Stack has a weak learning curve which is not related to the amount and quality of the documentation at one's disposal, but to the complexity of Angular when compared with React. Since it was aimed to reduce the learning time in order to leave more time to think about all the platform content and to focus on the user's need, the weak learning curve has weighted on the decision of the stack. However, there were other attributes that helped this choice such as the "packaging", the "**DOM**" and the "fail" and "binding" (see Table 3 of Section 3.2).

The "packaging" attribute is related to the number of packages available in the *npm* ecosystem. Although this *npm* ecosystem is available for all, the number of packages available for React is much higher than the ones available for Angular. This might have restricted the platform development and decreased the **UX** that we are trying to provide. Related to the "**DOM**" attribute, Angular uses the Regular **DOM** and React the Virtual **DOM**. The use of the Virtual **DOM** leads to a performance improvement by efficiently updating the view on a web app. The problem is not on the regular **DOM** used by Angular, but on all the time the browser takes to update all the **HTML** page whenever the **DOM** changes. By using the Virtual **DOM**, **DOM** changes are minimized since, as it has been explained on Section 3.5, only what has really changed is updated and the **UX** is increased. Lastly, the "fail" and "binding" attributes are linked to how React and Angular behave when there is a

typographical error and to debugging. By having React failing at the compile-time, the line-number where the error was made is printed making it easier to resolve it. Hence, the framework Angular fails silently at the runtime. On the other hand, by being Angular two-way binding it results on a cleaner code and it makes it easier to implement. Yet, the one-way binding of React makes the data flow in one direction leading up to a better data overview and, consequently, an easier debugging.

Overall, after learning how to work and connect the four technologies – MongoDB, Express.js, React and Node.js – the *MERN* Stack was quite easy to work with. The MongoDB, by being schema less and by having a clear object structure, allowed a more intuitive data storage. The Express.js simplified the connection with the server and the definition of routes based on HTTP methods and URLs are definitely a great advantage. These routes have eased the communication between the front-end and the database, making it simpler to ask by the front-end and retrieve by the database the data of interest.

5.2 SUPPORTING TOOL

The six modules implemented, and which are the focus of this work, aim to engage the users on the developed mHealth platform and also to monitor their pregnancy. The User's Home Module (Section 4.2.1) is the platforms dashboard after the login is made. It is the first thing the user encounters and must show the most important and needed data. In fact, the developed dashboard gives quick access to the tracking tools and to the Health and Well-being Module. Moreover, it also presents important information as the next medical appointment. This dashboard also allows the record of simple information that later may be used to monitor the pregnancy and alert if something is wrong. An example of that is the detection of intensive nausea and vomits during the second trimester and alert the user that she needs to talk about it with her doctor.

To link the three modules related with the health and well-being of the future mother, the Health and Well-being Module (section 4.2.2) has been created. This module is also useful to raise awareness on the importance of good habits and a healthy lifestyle during pregnancy.

The Pregnancy Log Module (Section 4.2.3) is an important module which allows future moms to monitor their food intake, physical activity or any other thing that they might need to record and compare it to previous records. For women who are overweight/underweight, recording this information might be beneficial to them and might also make them more aware of what needs to change on their meals

through the day. Thus, the concept is needed and important for the platform. But even so, the UI is very primitive and needs to be improved. For example, the user is only able to add or delete data, but not to edit the data that has already been recorded.

The Foetal Development Module (Section 4.2.4), whose purpose was to weekly inform the pregnant women on the changes of the foetus, was developed using the module Carousel from the React-Bootstrap. Usually, this feature is one of the pregnant women's favourite and one they expect to find on pregnancy apps. The developed module allows women to navigate back and forth through the weeks. Overall, this module was well achieved, yet it would benefit from some elucidative images or videos since pregnant women find these features a way of connecting with their baby.

To monitor the future mother, some advice is given and weekly information on the changes their body is going through is provided. The advice given in the Advice for Future Moms Module (Section 4.2.5) is on topics such as nutrition, physical activity, nausea and dizziness, conditions that might happen during pregnancy and a summary with general tips for each trimester. Nutrition, physical activity, dizziness and the summary for each trimester are linked to the gestational age, which means that it is the gestational age that determines what is advised. Conditions that may happen during pregnancy and nausea are related to the information collected on the BSG or on the User's Home Module. However, this Advice for Future Moms Module is still on an early stage and needs more information to make it more user's specific and personal.

Finally, the Gestational Diabetes Record Module (Section 4.2.6) was the last tracking tool to be developed on this work. It was also successfully achieved, it keeps the records organised, it is easy for the user to add, update or delete any value and has a good UI. Maybe it would benefit if the user could check her values on a graphic representation as an extra to the tables, but that is not a necessity.

PROOF OF CONCEPT

The project here implemented, as any other **IT** project, must be analysed and tested before becoming available to its users. It is important to analyse the platform and understand if the pre-established aims have been accomplished. It is also essential to test how the users make use of the platform, which features are in fact useful to them and which need to be improved or added.

This chapter conducts a proof of concept to try to demonstrate its potential. Unfortunately there was no time to implement a usability test to understand how the users perceive the platform. Nonetheless, a usability test will be suggested on this chapter to be eventually implemented on the platform.

Thus, the first section of this chapter is about the *SWOT* Analysis. This concept is there introduced and explained how to benefit the most of its employment. Afterwards, the platform that has been described through this document is analysed. The second part of this chapter is dedicated to suggest a usability test.

6.1 SWOT ANALYSIS

6.1.1 *Background*

The *SWOT* Analysis, which is a great tool to assist the strategic planning and the decision making, is a simple and structured planning method that assesses the internal and external factors impact on the project [89]. Figure 23 represents the *SWOT* Matrix. The internal factors, the Strengths and Weaknesses that support or block organisations, are also the controllable ones. However, the external factors, the Opportunities and Threats to which the organisations are exposed, are uncontrollable [90].

Figure 23.: SWOT Matrix.



Hay and Castilla in [91] explain how to benefit from the *SWOT* Analysis. The information coming from the analysis should help with the decision making, it must be a meaningful analysis instead of a simple list of strengths, weaknesses, opportunities and threats. Each one of them should be dealt with as it follows [91]:

Strengths – they are the helpful attributes of the organisation, which will lead to the achievement of the goals. Here some questions should be asked, such as: How can we use each Strength? Or what do we do better than anyone else?

Weaknesses – these are the harmful attributes of the organisation, which might be an obstacle to the objectives achievement. Here the questions asked might be: How can we stop each Weakness? Or what and where can we improve? Or even what are others likely to see as weaknesses?

Opportunities – these can be defined as external conditions or attributes of the environment that may make it possible to achieve the objectives. The questions raised are: How can we exploit each Opportunity? Or what trends could we take advantage of? Or even how is it possible to turn the Strengths into Opportunities?

6.1.2 *SWOT Analysis of the Developed Platform*

By having in mind the concept of a *SWOT* Analysis previously referred to and being the developed platform the "organisation" that must be analysed, the strengths and weaknesses as well as the threats and opportunities must be identified. Through this evaluation of the platform the six modules developed through this dissertation will be considered.

Regarding the strengths, the following points were identified:

- High scalability: the architecture is simple and the ideal to the platform scale;

- A quicker loading of the content;
- The responsive interface;
- The access to a significant number of pregnancy monitoring tools;
- The advice given accordingly to the pregnant women gestational age and medical history.

On the other hand, the developed supporting tool has some weaknesses that have been identified as:

- The platform isn't yet completely available offline;
- The need that pregnant women have to fill all the data on the [BSG](#) to have access to personalised information;
- Some features of the developed tool need to be improved.

The external factors which influence this platform positively, opportunities that cannot be controlled, are:

- The free availability of the platform;
- The pregnant women's expectations on having access to more reliable and personalised platform;
- The need of increasing the pregnant women's knowledge and the incentive to a healthy lifestyle.

At last, the external threats to the work here developed are:

- The competition with other pregnancy apps already available on the market;
- The lack of engagement pregnant women might have to this new technology.

6.2 USABILITY TEST

Performing a usability test to the implemented platform is a really important step. It would allow to study possible changes that may improve the platform as well as to detect existent development flaws. However, there was no time to implement a usability test and it would be interesting to implement it only when all the platform is completely modified to be totally available offline.

Nevertheless, in this section it is suggested an online usability test that might be

incorporated on the developed platform. This aims to identify the users' opinion and how useful the platform is to them. A survey is suggested here as the usability test. This method is an advantageous approach since it is quick and direct to execute and its results are easy and objective to be analysed.

The work described on this dissertation has ended with the implementation of six modules: User's Home Module, Health and Well-being Home Module, Pregnancy Log Module, Foetal Development Module, Advice for Future Moms Module and Gestational Diabetes Record Module. In spite of being a part of an entire platform, the usability test here proposed focus on evaluating these six modules.

The suggested survey is divided into seven parts. The personal information is collected on the first part of this survey. If the user denies being diagnosed with gestational diabetes or diabetes mellitus, then she must skip the sixth section. Most of the parameters on this survey are assessed by a quantitative evaluation. A score from 1 to 5 must be given in this evaluation. The first and third questions of the "First section – Personal Information" are to be answered with Yes or No and the options for the age group are: -18, 18–24, 25–29, 30–34, 35–40 and 40+. Besides, the three first questions of the "Seventh section – General" are to be answered by a free text input, the fourth question by giving a score between 1 to 5, and the last one by Yes or No.

First section – Personal Information

- Is it your first pregnancy?
- What is your age group?
- Have you been diagnosed with diabetes mellitus or with gestational diabetes during your pregnancy?

Second section – User's Home Module and Health and Well-being Home Module

- Is the interface design pleasant?
- How intuitive did you find these modules?
- How useful did you find these modules?
- How reliable and flawless did you find these modules?
- What is your evaluation to these modules?

Third section – Pregnancy Log Module

- Is the interface design pleasant?
- Is the information well organised?
- How useful did you find this module?
- How intuitive did you find this module?
- How reliable and flawless did you find this module?
- What is your evaluation to this module?

Fourth section – Foetal Development Module

- Is the language simple and appropriate?
- How useful did you find this module?
- How reliable and flawless did you find this module?
- What is your evaluation to this module?

Fifth section – Advice for Future Moms Module

- Is the language simple and appropriated?
- Is the information well organised?
- How reliable did you find the information?
- Was the information provided to you adequate?
- How useful did you find this module?
- How reliable and flawless did you find this module?
- What is your evaluation to this module?

Sixth section – Gestational Diabetes Record Module

- Is the information well organised?
- How useful did you find this module?
- How reliable and flawless did you find this module?
- What is your evaluation to this module?

Seventh section – General

- Which module do you use the most?
- What are the main flaws?
- What aspects would you like to see changed on the previous modules?
- Overall, what is your evaluation of the developed tool?
- Would you suggest this tool to your friends?

In order to encourage the users to adopt this supporting tool and to increase their satisfaction, the main objective of this test is to understand which modules need to be improved and what are their flaws. It also aims to apprehend what is the users' perception when they use the platform. Therefore, it was chosen to give each module a section on the survey. Despite having some repeated questions along the survey, this will allow a more precise identification of the modules that need to be worked on.

CONCLUSION

This dissertation ends with a brief conclusion. Here the main reached contributions are presented through the development of the supporting tool for future mothers. Besides, in this chapter it is also proposed future aims which might lead to this project improvement and continuation.

At the beginning of this document, at Section 1.3, five RQs were raised. This chapter seizes the opportunity to answer these questions in its first section – Main Contributions – as well as to present the main conclusions of the developed work. Moreover, a second section is written to establish a possible direction for the future work.

7.1 MAIN CONTRIBUTIONS

The major aim of this dissertation was to develop a supporting tool for future mothers from scratch in cooperation with CMIN. This assistance to women during pregnancy should be given by a mobile platform and this supporting tool that was developed has three main parts. One of these parts, and that is related to monitoring pregnancy, led to the development of the modules that were described throughout this dissertation. The methodology followed, and which allowed to design and implement a successful IT solution, was the DSR. Hereafter, the RQs raised in Section 1.3 can now be answered.

A detailed analysis of the types of mobile development have been performed and the advantages and the disadvantages of each one have been studied. To develop a web app would be the quickest and easiest way to develop the platform. However, it would be nothing more than a website available through the mobile web browser and it would need internet connection to work. Deciding on developing a native app would have been a good choice if we had some experience on the mobile development and if it wasn't needed to develop a cross-platform mobile app. Hybrid apps have the response for this problem, they provide a mechanism that would allow to develop a cross-platform mobile app without all the extra time that would

take to develop different native apps. Yet, the cutting-edge technology of *PWA*, a web app that could be used on smartphones as a normal mobile app and even work offline, has proven to be the best choice for this project. Since a *PWA* is based on web apps, it uses web technologies on the development: *JS*, *HTML* and *CSS*. Thus, the request made was to choose a stack with only one programming language - the *JS*. The main doubt was between the *MEAN* and the *MERN* Stacks. Both use MongoDB for the database and Express.js and Node.js for the back-end. The main difference was on the front-end development. *MEAN* Stack uses the framework Angular and *MERN* Stack the library React. The advantages React would bring to the project by being easy to learn, by using a Virtual *DOM* and by having a higher support by the *npm* ecosystem, among others, made the *MERN* Stack our choice. The first *RQ* on how to develop a website and a cross-platform mobile app in a efficient way is, therefore, answered.

RQ 2 was related to the monitoring of the pregnancy by the platform. The monitoring provided by the platform, and external to the monitoring that is given by the components of the *BSG*, is through weekly information and advice given to the users. It also allows the tracking of moods, events, food intake, physical activity and blood sugar levels in case of having gestational diabetes or diabetes mellitus. In fact, to answer *RQ* 2 and to monitor the pregnancy through the platform, four modules have been developed to incorporate the supporting tool. Two of these modules only provide pregnancy-related information. Foetal Development Module provided weekly information on the evolution of the baby based on the gestational age. Advice for Future Moms Module gives weekly information on the changes occurring on mother's body and advice on nutrition, physical activity and conditions that may occur during the pregnancy based on the gestational age and on the health history. Yet, two other modules were developed to track mainly food intake and physical activity – Pregnancy Log Module – and to track blood sugar levels – Gestational Diabetes Record Module. The dashboard of the platform has also two tracking tools implemented where future mothers can record moods and pregnancy events and whose record might influence the advice given on the Advice for Future Moms Module.

To answer *RQ* 3, the last question related to the platform implementation, two dashboards were made and all the modules have a responsive interface. Yet, it was not possible to take full advantage of the *SW* potential provided by developing a *PWA* and the platform isn't fully accessible when offline. The main dashboard, User's Home Module, provides a quick access to all the tracking features of the platform, informs of the next medical appointment recorded, allows record of moods and

pregnancy events, gives information of the current gestational week and links to the Health and Well-being Home Module. This last module is another small dashboard by connecting the Pregnancy Log, the Foetal Development and the Advice for Future Moms Modules.

Eventually, the viability, utility and usability of the **IT** solutions were analysed through a Proof of Concept in order to answer **RQ 4**. This Proof of Concept included a **SWOT** Analysis and a suggestion of a Usability Test. Despite not having the results of the suggested Usability Test, from the **SWOT** Analysis performed it was possible to conclude that the supporting tool has a high scalability and the significant numbers of monitoring tools as well as the personalised advice given are part of its strengths. Nevertheless, some modules need to be improved and there is a competition with other pregnancy apps already available on the market. Hence, these are some of the weaknesses and threats to the work here developed.

7.2 PROSPECT FOR FUTURE WORK

RQ 5, which was about the aspects where the platform can be improved, is answered in this section. This project and the platform on which the modules described through this dissertation are inserted on the platform to support future mothers during pregnancy. However, this platform was built from scratch. It is still necessary to implement the last versions of the platform and of some of the modules described through this document and even to complete the conversion needed for working offline. This is one of the most important tasks since the utility of the developed platform is dependent upon that. Furthermore, it would also be important to conduct the usability test. Although there was no time to implement the proposed usability test, executing one would lead to new improvements of the platform.

On the other hand, it would be interesting to expand the platform to the **HIS**. By developing an interface for the obstetricians, they could have access to part of the information of their patients and, therefore, monitor them more closely. They would also be able to introduce more technical data in the **BSG** which, at this point, is introduced by pregnant women to have access to a more personalised information. Besides, the information provided in the platform to its users on the modules described could be directly written and updated by the obstetricians through their interface.

Finally, regarding the modules here implemented, the **UX** would be increased if educational videos or images related to the pregnancy and to the baby's development

were incorporated. More personalised information should be added to the Advice for Future Moms Module and the data collected on the tracking tools should be used to alert to dangerous situations. For instance, in spite of being normal, intense nausea and vomiting may cause dehydration. The Pregnancy Log Module should be improved and maybe change the mood tracking by a symptom tracking that would alert if some set of symptoms were selected. To enhance the UX even more, Push Notifications should be explored since the Google has made available two APIs for the PWA – Notifications API and Push API – to make that possible.

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APPENDIX

“The 10 moons” can be divided into three main parts, yet the focus of this work is to monitor pregnancy and to provide information on a healthy lifestyle. Thus, there were developed six modules whose interface, when accessed via smartphone, can be seen on the following figures.

Figure 24 shows the interface of the PWA when the user accesses through a smartphone to the User’s Home Module. When pregnant women navigate to the Health and Well-being Home Module, the interface provided by the PWA will be the one of Figure 25. On the right side of this interface there are the buttons that will link to the other modules: Pregnancy Log Modules (Figure 26), Foetal Development Module (Figure 27) and Advice for Future Moms Module (Figure 28). This last module advises future mothers during their pregnancy. The points in time when each advice is given are explained on the Section 4.2.5 and Figures 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42 and 43 show how each advice is given. When pregnant women access the Advice for Future Moms Module, they are provided with a short summary of each advice, which can be seen on the left side of Figures 29-43. The full advice, which can be seen on the right side of Figures 29-43, is shown when pregnant women click on the corresponding summary. Finally, Figure 44 shows the interface provided by the PWA when the user accesses the Gestational Diabetes Record Module through a smartphone.

Figure 24.: Interface of the User's Home Module when the user is online and on a smartphone.

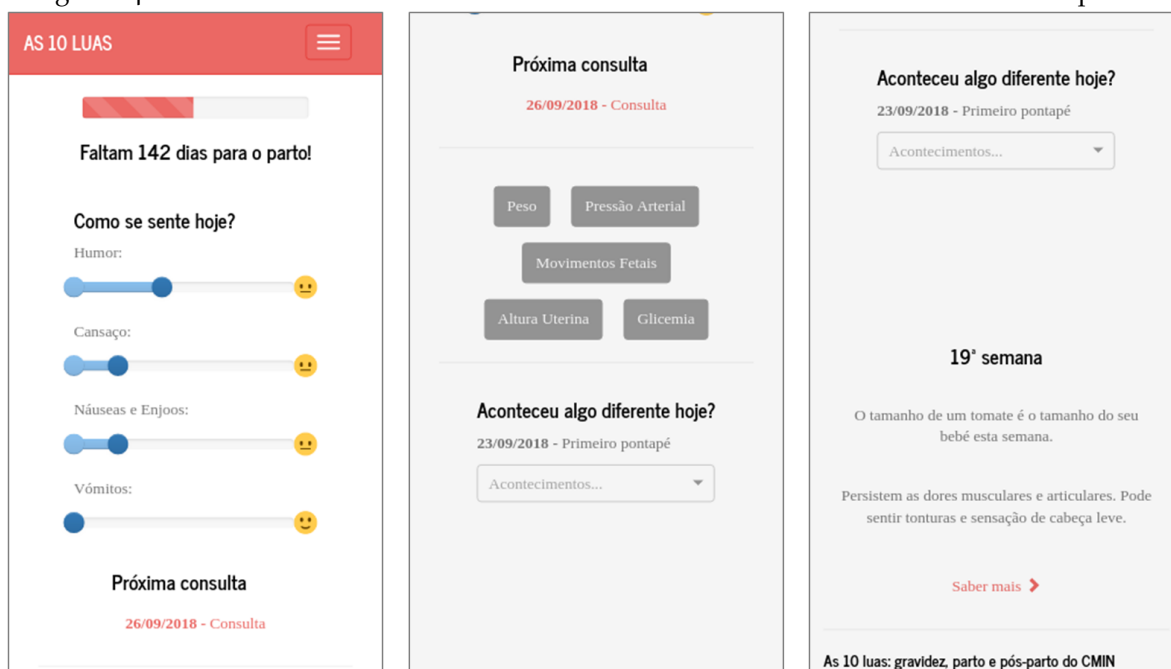


Figure 25.: Interface of the Health and Well-being Home Module when the user is online and on a smartphone.



Figure 26.: Interface of the Pregnancy Log Module when the user is online and on a smartphone.

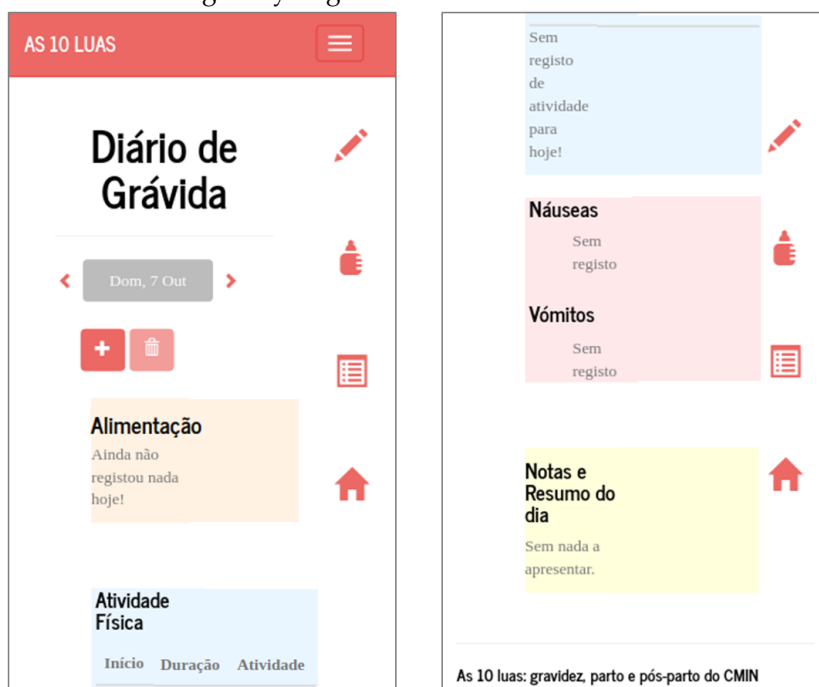


Figure 27.: Interface of the Foetal Development Home Module when the user is online and on a smartphone.

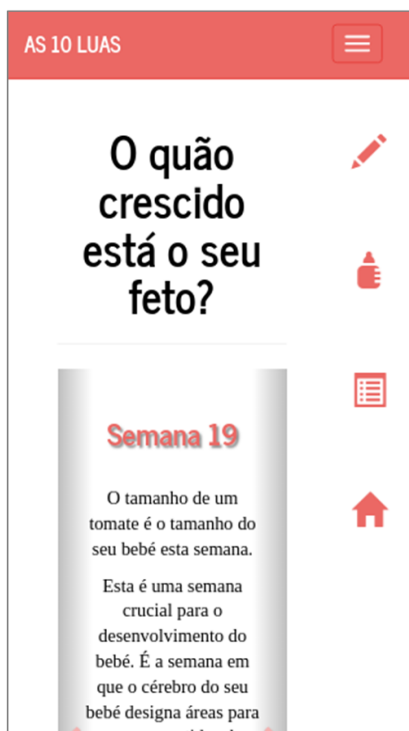


Figure 28.: Interface of the Advice for Future Moms Module when the user is online and on a smartphone.



Figure 29.: Summary and full text of the article "What to eat?".

O que comer?

Uma boa alimentação não só é importante para a manter saudável como também poderá facilitar o trabalho de parto e ajudar a que o seu bebé tenha um crescimento saudável.

O que comer?

Durante a gravidez a alimentação deve ser completa, equilibrada e variada, tal como deveria ser durante qualquer outro período da vida. Beber água também tem um papel muito importante, pois previne obstipação, hemorroidas e infeções urinárias. A água é responsável também por transportar os nutrientes para o bebé.

Para se certificar que tem uma alimentação completa, equilibrada e variada, procure obedecer aos três princípios que se seguem:

- Consuma alimentos de todos os grupos alimentares (cereais, de preferência integrais - pois têm a maior quantidade de fibra, vitaminas e nutrientes - e cerca de 200 gramas/dia, e derivados e tubérculos; hortícolas; frutas; lacticínios - são uma boa fonte de cálcio e proteínas -, carne (de preferência carne branca), peixe e ovos; leguminosas; gorduras e óleos - as melhores fontes são óleo de canola, azeite e óleo de cártamo bem como peixe, abacate, frutos secos, sementes e azeitonas.
- Consuma de cada grupo referido numa proporção equilibrada.
- Dentro de cada grupo não consuma sempre o mesmo alimento. É importante variar o tipo de alimentos consumidos. Por exemplo, para se certificar de que varia nas frutas que come, procure comer sempre frutas de cores diferentes. Frutas com muita fibra previnem hemorroidas e constipações. Vegetais verdes escuros são uma boa fonte de ferro e ácido fólico.

Alimentos a evitar:

- Lacticínios não pasteurizados;
- Queijos mal curados;
- Queijo fresco e requeijão;
- Enchidos e fumados;

Figure 30.: Summary and full text of the article "Essential nutrients".

Nutrientes Essenciais

Existem alguns nutrientes essenciais que deve integrar na sua alimentação. Aqui dizemos-lhe quais e qual a sua importância!

Nutrientes Essenciais ×

Proteína - Durante esta fase da sua vida é importante o consumo de aminoácidos. Estes são fundamentais para construir as células do seu corpo e do corpo do seu bebé. Uma proteína é formada por um conjunto de aminoácidos, por isso, o segredo para consumir mais aminoácidos é consumir mais proteína.

Deve consumir o equivalente a dois baralhos de cartas de proteína. Pode encontrar em carnes de preferência brancas, peixe, laticínios e ovos. Uma excelente fonte de proteína são também os feijões (lentilhas, feijão preto, feijão vermelho, grão-de-bico e feijão rajado) e o tofu. Tenha cuidado com o peixe que consome, deve evitar os grandes peixes, que são também grandes predadores, pois podem conter mercúrio – metal perigoso para o desenvolvimento do cérebro do seu bebé.

Cálcio - O cálcio é outro nutriente essencial à sua dieta, uma vez que este é necessário para os ossos e dentes do seu bebé. O cálcio também é fundamental para o desenvolvimento do sistema circulatório, dos músculos e nervos do seu bebé. Os laticínios são o principal grupo de alimentos que contêm cálcio, mas existem outros alimentos como tofu e soja; vegetais como brócolos e espinafres; sardinha; sementes de sésamo; de linhaça e chia; grão-de-bico; e aveia.

Magnésio - O cálcio serve também para estimular a contração muscular, e o movimento oposto, ou seja, a relaxação muscular é assegurada pelo magnésio. Este nutriente encontra-se em grande quantidade nas algas, nos cereais integrais, em alguns peixes, nos vegetais de cor forte e ainda em alguns legumes.

Fósforo - O fósforo é um nutriente que auxilia na formação de ossos saudáveis tanto em si como no seu bebé como também na criação e utilização de energia pelo seu corpo. Também é indispensável para a coagulação do sangue e na manutenção do ritmo cardíaco, nas contrações musculares, nas funções renais e nas reparações de tecidos e células. Basta consumir um iogurte natural ou um copo de leite para estar a consumir fósforo.

Figure 31.: Summary and full text of the article "Essential vitamins".

Vitaminas Essenciais

Além dos nutrientes que são muito importantes durante a gravidez, também existem vitaminas essenciais.

Vitaminas Essenciais

Vitamina A - A vitamina A é importante para o desenvolvimento do sistema circulatório e coração, do sistema respiratório e pulmões, dos rins, olhos, ossos e do sistema nervoso. Basicamente, a vitamina A é importante para o crescimento embrionário do bebê. Contudo, além de desempenhar um papel importante no crescimento embrionário do bebê, também é essencial para a recuperação da mulher depois do parto. Pode ir buscar esta vitamina à fruta, de preferência de cor laranja e amarela, e vegetais, principalmente aqueles com folhas verdes! O fígado é um alimento que possui uma quantidade de vitamina A tão elevado que bastaria consumi-lo uma porção para se ter ingerido mais de 8 vezes da dose diária recomendada de vitamina A.

Vitaminas do complexo B - As vitaminas do complexo B ajudam o corpo a converter a comida em energia e desempenham também um papel importante no desenvolvimento do bebê.

Vitamina B1 - A vitamina B1, também conhecida por tiamina, é essencial para o desenvolvimento do cérebro e para o correto funcionamento do sistema nervoso, dos músculos e do coração. Esta vitamina pode ser encontrada em pães, cereais e produtos integrais fortificados, carne de porco magra, feijões e ervilhas. Embora em menor quantidade, as frutas, os vegetais e os laticínios também contêm esta vitamina.

Vitamina B2 - A vitamina B2, ou riboflavina, além de ser uma mais-valia para o sistema nervoso, músculos e coração como a vitamina B, é também para o desenvolvimento e crescimento do bebê, para que ele tenha uma boa visão e uma pele saudável. Pode encontrar esta vitamina no pão, em alimentos com farinha de trigo, leite, cereais fortificados, ovos e espinafres.

Vitamina B3 - A vitamina B3, ou niacina, ajuda na produção das hormonas sexuais e é importante para a circulação. Algumas fontes desta vitamina são os laticínios, o germe de trigo, a gema de ovo, a carne e o fígado.

Figure 32.: Summary and full text of the article "Nausea and Sickness".

Naúseas e Enjoos

As náuseas e os enjoos são característicos do primeiro trimestre, por vezes até são o primeiro sinal de gravidez para algumas mulheres...

Clique aqui para saber quais as nossas dicas para os atenuar.

Naúseas e Enjoos

As náuseas e os enjoos são característicos do primeiro trimestre, por vezes até são o primeiro sinal de gravidez para algumas mulheres. Ocorrem sobretudo devido às alterações hormonais e a uma maior sensibilidade aos odores. Se está com dificuldades em manter a comida no estômago, experimente algumas das nossas dicas. Mantenha o seu diário atualizado se forma a que você saiba quais as alturas do dia em que se sente com mais náuseas. Assim poderá saber o que fazer para que estas melhorem e quais as melhores alturas para comer algo. Se nada resultar não desespere e lembre-se que as sensações de náuseas e enjoos terão um fim algures entre o terceiro e quarto mês de gravidez.

Dica 1 - De manhã, quando acordar, coma algo (uma fatia de pão ou umas bolachas) na cama antes de se levantar. Descanse 20 minutos e só depois é que salte fora da cama. Por vezes, sair da cama de estômago vazio pode levar a que se sinta enjoada.

Dica 2 - Opte por comer com mais frequências (cerca de 5 a 7 refeições por dia) e por fazer pequenas refeições ou lanches que lhe confortem o estômago, a alimentem e que sejam de fácil digestão.

Dica 3 - Por vezes alterar a dieta pode ajudar. Tenha uma dieta com baixo teor de gordura e de fácil digestão, evitando comer fritos e refeições muito condimentadas. Dê preferência às proteínas e aos hidratos de carbono.

Dica 4 - Não coma com pressa. Coma num ambiente descontraído, mastigue bem os alimentos e com calma. Comer comida fria ou à temperatura ambiente pode ajudar a controlar as náuseas e os enjoos.

Dica 5 - Beba água em abundância entre as refeições. É importante manter-se hidratadas. Se comida sólida a deixa enjoada, então procure comer sopas e caldos. A água com gás pode ajudar a acalmar o enjoo.

Dica 6 - Escove os dentes e use um elixir bucal, depois de comer, para remover quaisquer

Figure 33.: Summary and full text of the article "Nausea and Sickness - 2nd trimester".

Náuseas e Enjoos-2º Trimestre

Náuseas e Enjoos no segundo trimestre não são normais. Se continua a tê-los com alguma frequência, então deve falar com o seu médico.

Náuseas e Enjoos-2º Trimestre ×

Fale com o seu médico sobre as náuseas e/ou vômitos. Esta indisposição pode deixá-la exausta e, quando em demasia, podem provocar desidratação ou não a deixar ganhar o peso necessário para que tenha uma gravidez saudável.

Dica 1 - De manhã, quando acordar, coma algo (uma fatia de pão ou umas bolachas) na cama antes de se levantar. Descanse 20 minutos e só depois é que salte fora da cama. Por vezes, sair da cama de estômago vazio pode levar a que se sinta enjoada.

Dica 2 - Opte por comer com mais frequências (cerca de 5 a 7 refeições por dia) e por fazer pequenas refeições ou lanches que lhe confortem o estômago, a alimentem e que sejam de fácil digestão.

Dica 3 - Por vezes alterar a dieta pode ajudar. Tenha uma dieta com baixo teor de gordura e de fácil digestão, evitando comer fritos e refeições muito condimentadas. Dê preferência às proteínas e aos hidratos de carbono.

Dica 4 - Não coma com pressa. Coma num ambiente descontraído, mastigue bem os alimentos e com calma. Comer comida fria ou à temperatura ambiente pode ajudar a controlar as náuseas e os enjoos.

Dica 5 - Beba água em abundância entre as refeições. É importante manter-se hidratadas. Se comida sólida a deixa enjoada, então procure comer sopas e caldos. A água com gás pode ajudar a acalmar o enjoo.

Dica 6 - Escove os dentes e use um elixir bucal, depois de comer, para remover quaisquer vestígios de comida da boca.

Dica 7 - Experimente tomar as vitaminas que tem de tomar com comida, com um pequeno lanche rico em proteína (algumas sugestões são iogurte, queijo, nozes, aveia, manteiga de amendoim), antes de se deitar. E leve para a sua mesinha de cabeceira algumas bolachas, pois poder-lhe-ão ser úteis caso as náuseas ataquem a meio da noite.

Figure 34.: Summary and full text of the article "Dizziness".

Tonturas

Sentir algumas tonturas durante a gravidez, quer estas sejam devido ao calor, fome, ou por se levantar demasiado rápido, é normal! Contudo, se estas forem frequentes, se verificar períodos de tonturas ou uma frequente sensação de que vai desmaiar, fale com o seu médico!

Tonturas

Lembre-se que é importante iniciar a toma de ácido fólico, se ainda não o fez. O ácido fólico é fundamental para o desenvolvimento da espinal medula e do cérebro do bebé... Fale com o seu médico!

Com o aumento do volume sanguíneo a cada semana que passa é normal que surjam algumas tonturas. O seu sistema cardiovascular está a atravessar grandes mudanças para se adaptar ao desenvolvimento do seu bebé. Durante esta primeira metade da gravidez, as alterações hormonais fazem com que os vasos sanguíneos relaxem e se expandam para aumentar o volume de sangue que chega ao seu bebé. Contudo, isto diminui também a pressão arterial e diminui a quantidade de sangue que vai para o cérebro e para o coração provocando-lhe tonturas.

Algumas dicas para prevenir as tonturas são:

Dica 1 - Sempre que se puser de pé faça-o devagar e com cuidado. Quando se senta, o sangue fica acumulado nas suas pernas. Se se levantar demasiado rápido, o sangue não tem tempo de retornar das suas pernas para o seu coração deixando-a tonta.

Dica 2 - Sempre que se deitar, não se deite de costas. Deite-se de lado.

Dica 3 - Esta dica é também importante para prevenir as náuseas. Mantenha-se hidratada e opte por fazer refeições pequenas e frequentes. Desta forma, ao comer com regularidade, estará a prevenir que o nível de açúcar no sangue desça demasiado (o que pode provocar também tonturas).

Dica 4 - Certifique-se que anda a ingerir a quantidade de ferro necessária. Se estiver anémica terá menos glóbulos vermelhos para carregar oxigénio até ao seu cérebro e até aos restantes órgãos. Isto poderá deixá-la tonta.

Dica 5 - Evite sobreaquecer o seu corpo. O excesso de calor a que está sujeita ora num ambiente quente ora enquanto toma um banho quente pode provocar a dilatação dos vasos

Figure 35.: Summary and full text of the article "Gestational Diabetes".

Diabetes Gestacionais

Durante a gravidez, por vezes, o corpo não produz quantidades suficientes de insulina e pode surgir diabetes gestacionais... Quer saber mais?

Diabetes Gestacionais

O sistema digestivo transforma grande parte da comida ingerida num açúcar chamado de glicose. A glicose entra na corrente sanguínea para que depois as células a utilizem como fonte de energia. Contudo, para que as células absorvam a glicose é necessário a presença de insulina – uma hormona produzida pelo pâncreas. Num organismo saudável a quantidade de insulina produzida é suficiente para a quantidade de glicose em circulação no sangue e aumenta após as refeições. Quando o corpo não produz quantidades suficientes de insulina ou se as células tiverem problemas a responderem à insulina, há um aumento dos níveis de açúcar no sangue em vez de estar a ser utilizado pelas células para ser convertido em energia.

De forma a garantir que o seu bebé recebe a quantidade necessária de glicose, durante a gravidez o seu corpo fica mais resistente à insulina. Isto não é necessariamente um problema, com o aumento de glicose no sangue o pâncreas é capaz de produzir mais insulina. No entanto há futuras mães cujo pâncreas não consegue acompanhar este aumento. Como consequência aumenta os níveis de açúcar no sangue surgindo a diabetes.

A diabetes gestacional surge, então, em grávidas que, antes da conceção, não tinham diabetes e desaparece com o término da gravidez. Contudo, ter diabetes na gravidez aumenta a probabilidade de vir a desenvolver, mais tarde, diabetes do tipo 2 se não forem tomadas as medidas de prevenção necessárias. Se a diabetes gestacional não for detetada na análise de hiperglicemia e corrigida seguindo uma dieta equilibrada proposta pelo nutricionista, por vezes com insulina, pode provocar problemas e complicações para o bebé e para a mãe.

Níveis elevados de insulina e açúcar na corrente sanguínea podem levar a que o seu bebé tenha excesso de peso e um tamanho acima do normal. Ambos fatores dificultam o parto vaginal. Mesmo depois do bebé nascer, os níveis elevados de açúcar que estavam no sangue da mãe levam a que haja um excesso de insulina produzido pelo bebé, isto é, o bebé ter os níveis de açúcar no sangue demasiado baixos. O seu bebé pode também vir a ter problemas de respiração.

Figure 36.: Summary and full text of the article "Gestational Diabetes" which is shown when gestational diabetes is diagnosed.

Diabetes Gestacionais

Foi-lhe diagnosticado diabetes gestacionais? Temos algumas dicas para si!

X

Diabetes Gestacionais

Apercebemo-nos que lhe foi diagnosticado diabetes gestacionais. Não se preocupe, ajudaremos a ultrapassar esta fase. Se começar a ficar muito preocupada com algum assunto, fale com o seu médico. Para já é importante que:

- Siga, com rigor, o plano indicado pelo nutricionista;
- Inicie, se ainda não o fez, uma dieta cuidada e equilibrada;
- Evite a ingestão de grandes quantidades de açúcar. Pode ser complicado deixar de comer certas coisas que gosta. A nossa sugestão é fazer uma troca inteligente. Troque os alimentos que lhe fazem mal por alternativas saudáveis. Tenha atenção aos hidratos de carbono que consome. Procure comer alimentos com grande teor em fibra, como pão, massa e arroz integrais (em vez de pão branco, arroz e massa refinada). A digestão dos alimentos com elevado teor em fibra é mais demorada e, por isso, a libertação de açúcar para o sangue mais lenta. Outros alimentos ricos em fibra são os vegetais e as leguminosas. Evite comidas e bebidas com elevados valores de açúcar como doces, bolos e refrigerantes. Opte por alimentos como carnes brancas, peixe e productos lácteos magros como fontes de proteína. Evite gorduras saturadas, como manteiga, e hidrogenadas, como as que se encontram nos alimentos processados. De vez em quando cozinhe para si própria pequenas recompensas com baixo ou nenhum açúcar;
- Faça uma caminhada diária de pelo menos 30 minutos;
- Vigie os valores de glicemia. Para manter os diabetes controlados não basta apenas estar atenta ao que se come. Deve-se estar também atenta a como e quando se come. No seu diário pode registar o que tem comido e a que horas bem como os níveis de açúcar no sangue (medição da glicemia);
- Deve controlar de forma eficaz o aumento de peso de modo a não aumentar mais do que o previsto. Manter os níveis de açúcar estáveis através de uma alimentação saudável e da

Figure 37.: Summary and full text of the article "Underweight".

Baixo Peso

Ter baixo peso no início da gravidez acarreta um conjunto de riscos para o seu bebé.

X

Baixo Peso

O seu imc está abaixo do valor normal, ou seja, durante a gravidez terá de aumentar de peso um bocadinho mais que as restantes mães com um imc normal.

Ter baixo peso no início da gravidez aumenta o risco de ter um parto prematuro ou que o seu bebé seja pequeno para a idade gestacional. Mas não se preocupe que ganhar peso de consistente ao longo da gravidez reduz estes risco. Opte por alimentos com um bom valor nutricional, que contenham gorduras saudáveis. Nunca salte ou se esqueça de tomar o pequeno almoço! E não passe muitas horas sem comer! Coma dois ou três snacks entre refeições.

Fale com o seu médico pois, além de ter de tomar um suplemento de ácido fólico, poderá também ser necessário iniciar a toma de um suplemento vitamínico.

Fechar

Figure 38.: Summary and full text of the article "Physical Activity – How to start?".

Exercício Físico - Como começar?

Praticar exercício físico durante a gravidez coloca-a num bom estado de espírito e prepara-a para o parto. Se não pratica exercício físico, ou mesmo que pratique, temos algumas dicas que lhe poderão ser úteis.

Exercício Físico - Como começar?

Mesmo que não costume praticar exercício físico, muito provavelmente pode começar a praticar exercício físico durante a gravidez. Lembre-se que não é suposto perder peso durante o período de gravidez nem começar a praticar nenhuma atividade física de forma intensiva. Durante o período de gravidez não deve praticar nenhuma atividade até à exaustão.

Pode experimentar praticar cerca de 30 minutos de atividade física na maior parte dos dias, mas ouça o seu corpo e peça sempre a opinião ao seu médico.

Como começar?

Comece devagar fazendo, nas primeiras duas semanas, 10 a 15 minutos por dia. Quando se sentir confortável, adicione mais 10 minutos de forma a fazer 20 a 30 minutos de exercício físico por dia. Durante este período de adaptação ao exercício físico, que deve demorar cerca de 3 a 4 semanas, procure apenas aumentar o tempo de atividade física e não a intensidade dos exercícios.

Quando atingir o tempo de atividade física que estabeleceu como objetivo, então pode abusar um bocadinho e aumentar a intensidade. Sempre que não conseguir dizer algumas palavras sem ter de parar de falar para respirar, então é porque está a praticar exercício físico com demasiada intensidade.

Quando praticar?

Durante o período de gravidez o seu corpo pode sobreaquecer mais rapidamente, uma vez que este não consegue libertar calor de forma eficiente num ambiente quente. Evite praticar exercício físico se estiver um tempo húmido e quente. As melhores alturas para a prática de atividade física são de manhã e ao final do dia, ou seja, evitando as alturas do dia de maior calor. Se não tiver como evitar praticar exercício físico durante estas alturas, então proteja-se das elevadas temperaturas.

Figure 39.: Summary and full text of the article "Activities to Avoid During Pregnancy".

Atividades a Evitar

Se já costumava praticar exercício físico antes da gravidez, confirme aqui quais as atividades que não são seguras durante a gravidez e alguns cuidados que deva ter durante a prática de exercício físico.

Atividades a Evitar

Se a sua gravidez não for uma gravidez de risco, muito provavelmente poderá continuar com a sua rotina. O ideal é praticar cerca de 30 minutos de atividade física de intensidade média. Lembre-se que não é suposto perder peso durante o período de gravidez nem praticar nenhum tipo de atividade até à exaustão. Certifique-se que se está a alimentar corretamente, pois a necessidade nutricional varia com o tempo gestacional. Ouça o seu corpo e peça sempre a opinião ao seu médico.

Durante o período de gravidez o seu corpo pode sobreaquecer mais rapidamente, uma vez que este não consegue libertar calor de forma eficiente num ambiente quente. Evite praticar exercício físico se estiver um tempo húmido e quente. As melhores alturas para a prática de atividade física são de manhã e ao final do dia, ou seja, evitando as alturas do dia de maior calor. Se não tiver como evitar praticar exercício físico durante estas alturas, então proteja-se das elevadas temperaturas.

Se praticar exercício físico no exterior, então proteja também a sua pele. Durante o período de gravidez a sua pele está mais sensível.

Dê especial atenção a manter-se hidratada tanto antes, como durante e depois de fazer exercício físico. Desidratação pode levar a um mais fácil sobreaquecimento corporal bem como provocar contrações.

Certifique-se que consegue manter uma conversa enquanto pratica exercício físico. Se não conseguir, então tem de diminuir a intensidade da atividade física.

Tenha em atenção também ao calçado que usa na prática de exercício físico, pois durante a gravidez é normal que os seus pés aumentem ligeiramente de tamanho devido ao fluido extra que o seu corpo retém e à hormona relaxina que é produzida durante a gravidez.

Se pratica uma atividade com pouco movimento, por exemplo, levantar pesos ou praticar yoga, mova-se de vez em quando (andando de um lado para o outro ou até mesmo no

Figure 40.: Summary and full text of the article "Physical Activity – 1st trimester".

O que Praticar? - 1º Trimestre

Corrida, caminhada, yoga, natação... estas são algumas das atividades perfeitamente seguras para praticar durante a gravidez.

O que Praticar? - 1º Trimestre

CAMINHADA:

Esta é um tipo de atividade simples e seguro, sendo por isso perfeito para praticar durante os 9 meses e para quem decidiu iniciar a prática de exercício físico. Caminhar melhora a saúde cardiovascular, ajuda a que se mantenha em forma e não tem nenhum custo extra nem precisa de equipamento especial.

AERÓBICA:

Durante a fase da gravidez deve procurar exercícios de aeróbica de baixo impacto, isto é, nada de saltos nem pontapés altos, para não levar as articulações à exaustão. Este tipo de atividade fortalece o sistema cardiovascular, sendo ótima para quem procura diminuir o cansaço que sente e sentir-se também com mais energia. Aeróbica também é excelente para a flexibilidade e manter a tonificação dos músculos que, durante esta fase, têm de suportar as alterações que o seu corpo atravessa.

Se optar por fazer aulas de aeróbica, avise o seu instrutor que está grávida. Peça-lhe, à medida que a gravidez avança, formas de atenuar o impacto de cada movimento que possam ser demasiado bruscos para a fase em que se encontra.

Use camadas de roupa fina para que possa tirar à medida que o exercício físico intensifica. Sempre que sentir que está a ficar demasiado cansada, antes de ficar exausta, pare ou faça uma pausa no exercício.

NATAÇÃO:

Esta atividade é ótima para quem está grávida, uma vez que ao praticá-la está-se a utilizar todos os músculos do corpo sem fazer pressão sobre as articulações e sem qualquer risco do corpo sobreaquecer. Como a água suporta o seu peso, não sentirá o peso extra da gravidez e é uma das formas mais seguras para as futuras mamãs praticarem exercício físico. Permite-lhe fortalecer os músculos, principalmente os braços e as pernas e o sistema circulatório.

Figure 41.: Summary and full text of the article "Physical Activity – 2nd trimester".

O que Praticar? - 2° Trimestre

Corrida, caminhada, yoga, natação... estas continuam a ser algumas das atividades perfeitamente seguras para praticar durante a gravidez, talvez tenha é de ter outros cuidados.

O que Praticar? - 2° Trimestre

CAMINHADA:

Esta é um tipo de atividade simples e seguro, sendo por isso perfeito para praticar durante os 9 meses e para quem decidiu iniciar a prática de exercício físico. Caminhar melhora a saúde cardiovascular, ajuda a que se mantenha em forma e não tem nenhum custo extra nem precisa de equipamento especial.

Durante o segundo trimestre da gravidez, a sua barriga começa a notar-se cada vez mais. Para que caminhar não se torne desagradável, tente manter uma boa postura. Se começar a sentir dor de costas, experimente usar uma faixa/cinta de gravidez que a ajude a suportar a barriga.

Balançar os braços à medida que caminha não só ajuda no equilíbrio e aumenta a intensidade do exercício, com também lhe poderão ajudar caso fique com as mãos inchadas. Também poderá colocar uma mochila leve às costas e segurar nas suas alças. Isto também ajuda a reduzir o inchaço.

AERÓBICA:

Durante a fase da gravidez deve procurar exercícios de aeróbica de baixo impacto, isto é, nada de saltos nem pontapés altos, para não levar as articulações à exaustão. Este tipo de atividade fortalece o sistema cardiovascular, sendo ótima para quem procura diminuir o cansaço que sente e sentir-se também com mais energia. Aeróbica também é excelente para a flexibilidade e manter a tonificação dos músculos que, durante esta fase, têm de suportar as alterações que o seu corpo atravessa.

Certifique-se que se encontra afastada (cerca de um braço de distância) das pessoas à sua volta. Com o aumento da sua barriga fica mais difícil manter o equilíbrio e também não queremos que acidentalmente seja empurrada.

NATAÇÃO:

Figure 42.: Summary and full text of the article "Physical Activity – 3rd trimester".

O que Praticar? - 3º Trimestre

Corrida, caminhada, yoga, natação... nós dizemos-lhe o que é que pode continuar a praticar e que cuidados deve ter!

O que Praticar? - 3º Trimestre ×

CAMINHADA:

Esta é um tipo de atividade simples e seguro, sendo por isso perfeito para praticar durante os 9 meses e para quem decidiu iniciar a prática de exercício físico. Caminhar melhora a saúde cardiovascular, ajuda a que se mantenha em forma e não tem nenhum custo extra nem precisa de equipamento especial.

No terceiro trimestre da gravidez convém não caminhar para longe evitando trilhos e terreno irregular.

Cada vez mais a sua barriga precisa de apoio adicional, caso contrário pode sentir dores na parte inferior das costas ou nos ligamentos redondos do útero. Experimente usar uma faixa/cinta de gravidez que a ajude a suportar a barriga.

Se sentir que a distância que antes caminhava é demasiada e que a deixa demasiado exausta, diminua o tempo de caminhada ou opte por o dividir caminhando duas vezes ao dia.

Informe sempre alguém da sua caminhada e leve o seu telemóvel consigo.

AERÓBICA:

Durante a fase da gravidez deve procurar exercícios de aeróbica de baixo impacto, isto é, nada de saltos nem pontapés altos, para não levar as articulações à exaustão. Este tipo de atividade fortalece o sistema cardiovascular, sendo ótima para quem procura diminuir o cansaço que sente e sentir-se também com mais energia. Aeróbica também é excelente para a flexibilidade e manter a tonificação dos músculos que, durante esta fase, têm de suportar as alterações que o seu corpo atravessa.

Neste momento a sua barriga de grávida deve estar gigante. Se estiver com dores nas costas ou nos ligamentos redondos do útero, experimente usar uma faixa/cinta de gravidez que a ajude a suportar a barriga.

Figure 43.: Summary and full text of the article "Pre-eclampsia".

Pré-eclâmpsia

Sabe o que é a pré-eclâmpsia? E quais os seus sintomas?

Pré-eclâmpsia ×

A pré-eclâmpsia e a eclâmpsia são complicações graves que podem ocorrer durante a segunda metade de gravidez ou até mesmo depois do seu bebé nascer. Estão relacionados com a elevada pressão arterial e a presença de proteína na urina durante a gravidez. Ainda não há certezas, mas a pré-eclâmpsia parece dever-se a problemas no crescimento dos vasos sanguíneos da placenta no início da gravidez.

Mulheres com idade superior a 40 anos e inferior a 18, histórico familiar ou gestação anteriores com pré-eclâmpsia, gravidez de gémeos, mulheres hipertensas, obesidade, diabetes mellitus são alguns dos grupos de risco. Ter certos cuidados durante a sua gravidez e procurar um estilo de vida saudável e equilibrado poderá ajudar o seu médico a diagnosticar pré-eclâmpsia com antecedência e evitar complicações.

Embora seja possível que não venha a sentir nenhum sintoma, alguns sintomas de pré-eclâmpsia e aos quais deverá estar atenta são:

- dor de cabeça persistente;
- inchaço anormal das mãos e rosto;
- aumento de peso repentino;
- alterações na visão;
- dor na zona superior do abdómen.

Fechar

Figure 44.: Interface of the Gestational Diabetes Record Module when the user is online and on a smartphone.

AS 10 LUAS
☰

Registro de Glicemia

+

Hoje
 No último mês
 Todas

Dia	Antes do pequeno-almoço	Depois do pequeno-almoço	Insulina
Para iniciar registo clique no botão no topo da página			

Dia	Antes do almoço	Depois do almoço	Insulina
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Todas

Dia	pequeno-almoço	pequeno-almoço	Insulina
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Dia	Antes do almoço	Depois do almoço	Insulina
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Dia	Antes do jantar	Depois do jantar	Insulina
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Dia	Hora	Valor
Para iniciar registo clique no botão no topo da página		

B

PUBLICATIONS

B.1 SMART MOBILE COMPUTING IN PREGNANCY CARE

Authors: Francisca Fonseca, Hugo Peixoto, José Machado and António Abelha.

Submitted in: The 34th International Conference on Computers and Their Applications (CATA 2019)

Year: 2019

Abstract: Pregnancy is a period of changes. With all the information available and all the questions raised, it may also be an overwhelming period. Mobiles phones might be a solution for pregnant women to follow their pregnancy through Electronic Maternity Records (EMR). Therefore, this paper aims to propose an EMR to help women during their pregnancy. Firstly, the importance of Personal Health Records (PHRs) as well as mHealth is overviewed. Secondly, the types of mobile apps are presented with their pros and cons and the concept of Progressive Web App (PWA) is introduced. In order to understand the features that pregnancy mobile apps are now offering and the ones they are missing, eight apps are analysed. Lastly, the features and architecture of the proposed EMR are described and discussed. Since PWAs are a recent technology and a promising alternative to the three classic types of mobile development, it is also the technology used to develop the proposed EMR.

B.2 IMPROVING MATERNITY CARE WITH BUSINESS INTELLIGENCE

Authors: Patrícia Loreto, Francisca Fonseca, Ana Morais, Hugo Peixoto, António Abelha and José Machado.

Published in: Proceedings - 2017 5th International Conference on Future Internet of Things and Cloud Workshops, W-FiCloud 2017

Year: 2017

Abstract: The aim of this paper is to develop clinical indicators for obstetrics through the use of Business Intelligence (BI) tools, since valid and reliable clinical indicators can help measuring quality of healthcare services and support decision-making processes. This paper gives an overview of concepts related to Health Information Systems (HIS) and BI, along with some related work to highlight the advantages that BI solutions can bring when applied to healthcare. In this paper is also presented the data warehousing and the ETL process, that was necessary for the development of indicators and which is usually hidden from endusers, is described. The indicators were developed using Power BI and were analysed and compared with reference values from both national and international health reports. The discussion of the developed indicators made it possible to measure the quality of the obstetrics service, to identify the problematic areas and to decide whether improvement measures should be taken.

B.3 STEP TOWARDS PREDICTION OF PERINEAL TEAR

Authors: Francisca Fonseca, Hugo Peixoto, Filipe Miranda, José Machado and António Abelha.

Published in: Procedia Computer Science

Year: 2017

Abstract: The aim of this study is to predict, through data mining tools, the incidence of perineal tear. This kind of laceration developed during child delivery might imply surgery and entails a set of several consequences. Clinical Decision Support Systems, with the information collected from patients' electronic health records combined with the data mining techniques, may decrease the incidence of perineal tears during labour.

B.4 PREDICTING THE OCCURRENCE OF LUNG METASTASES IN SOFT TISSUE SARCOMA PATIENTS

Authors: Ana Morais, Francisca Fonseca, Patrícia Loreto, Victor Alves, Bruno Fernandes, Jorge Ribeiro, Cesar Analide, Filipa Ferraz, João Neves, Henrique Vicente and José Neves.

Published in: 16th Ibero-American Conference on Artificial Intelligence and the Sociedad Peruana de Inteligencia Artificial

Year: 2018

Abstract: Soft Tissue Sarcomas (STSs) pose a potential risk for the development of

lung metastases, which in turn results in a negative prognosis for patients. Indeed, the prediction of the occurrence of these anomalies during STS treatment would be of great interest to both patients and healthcare professionals as it could increase treatment efficacy and improve overall survival. Next, the techniques used and the problem-solving methodology for performing the feature extraction are presented, followed by a Logic Programming approach to feature vector representation that caters for the handling of incomplete, unknown or even self-contradictory data or knowledge. It is complemented with a Case Based approach to computing.

B.5 PREDICATIVE VAGUENESS IN LUNG METASTASES IN SOFT TISSUE SARCOMA SCREENING

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Abstract: Soft Tissue Sarcomas (STSs) pose a potential risk for the development of lung metastases, which in turn results in a negative prognosis for patients. Presumptions about the occurrence of these abnormalities during STSs treatment would have countless implications for both patients and healthcare professionals as they could increase the efficacy of the treatment and improve overall survival. Prediction is based on a creative Logic Programming, Case Based Reasoning approach to problem solving, that is complemented with an unusual approach to Knowledge Representation and Reasoning, as it takes into consideration not only the data items entropic states but introduces the concept of Vague's Predicate Extension.

NB: place here information about funding, FCT project, etc in which the work is framed. Leave empty otherwise.