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# **Evaluation of information services and needs for pregnant women, fathers and infants in China**

Information Systems Science/ Department of Management and Entrepreneurship

Master's thesis

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### **Abstract**

According to the statistics from the Ministry of Industry and Information Technology, as of June 2023, China's online population has reached 1.079 billion people, an increase of 11.09 million people compared to December 2022, with an internet penetration rate of 76.4%. With the rapid development of the big data era, users' dependence on the internet is increasing, not only bringing a substantial user base to the mobile internet market but also fostering the flourishing development of mobile applications. In the online environment, users engage in sharing experiences through posting and commenting on mobile applications (APPs) within online communities. This information holds significant value for exploring user needs and satisfaction. This study aims to combine content analysis of academic literature and text mining of APP forum comments to delve into the differences between information services provided by maternal and infant health-related APPs and the demands of users for maternal and child health information. It also aims to provide targeted improvement suggestions for health information services offered by maternal and child health-related mobile applications.

The paper begins by summarizing the current research status of maternal and child health information demands and services both domestically and internationally, subsequently formulating research questions. It then dissects the categories of maternal and child health information demands using the research method of grounded theory. The study utilizes open coding, axial coding, and selective coding on collected online academic literature, forming a three-tier framework for maternal and child health information demands. Following this, text mining is employed to preprocess question-and-answer and comment texts obtained from APP online communities. The TF-IDF algorithm is applied to extract high-value feature words from comment texts, which are then subjected to clustering and frequency statistics. This process supplements the three-tier framework for maternal and child health information demands. Qualitative content analysis is conducted to manually code video and article content in the APP, extracting three-tier categories of information services. Lastly, by comparing and analyzing the categories of maternal and child health information demands with the categories of health information services extracted from the APP, differences between the two are identified. The paper concludes by offering reasonable suggestions for the development and operation of maternal and child health-related applications.

The research findings demonstrate that maternal and child health information needs can be categorized into six main themes, 15 subcategories, and 68 tertiary categories. Maternal and child health information services comprise four categories, 15 subcategories, and 53 tertiary categories. There exists a notable disparity between maternal and child health information needs and services, particularly evident in prenatal examinations, fetal development, infant feeding and care, prenatal preparation, preconception knowledge and precautions, infant education, reproductive policies, and matters related to work and maternity leave. The study reveals the gap between information needs and services in the field of maternal and child health, pinpointing specific gaps in requirements during the prenatal, antenatal, and infancy stages, thereby offering targeted directions and focal points for improving maternal and child health services.

Based on these research findings, this paper proposes recommendations for the development of high-quality information services for maternal and child health apps from two perspectives: the organization and implementation of software systems and the categories of information services. From the viewpoint of software system organization and implementation, it is suggested to enhance and optimize functional design, refine facet system design, and structure information needs. From the perspective of information service categories, it is recommended to establish a specialized preconception advice module, provide pregnancy health monitoring and knowledge dissemination, comprehensive infant feeding and care information, as well as policy and institutional guidelines. These recommendations aim to enhance the quality of maternal and child health apps by improving software functionality design and providing professional information service content, enabling users to conveniently access comprehensive and effective information tailored to preconception, pregnancy, and childcare stages, thereby fostering maternal and child health development.

**Key words:** Maternal and Child Health, Information Demands, Information Services, Text Mining.

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# 1 INTRODUCTION

This research aims to find out the gap between information services and needs of maternal and infant health APP. This introductory chapter firstly interprets the aim of the study, research background, research questions, research significances and structure of the thesis.

## 1.1 Research background

With the continuous development and updating of internet technology and applications, healthcare applications that integrate social and information services are constantly emerging. Different types of online social platforms have become important channels for the public to obtain information (Mosa et al., 2012). With the popularity and promotion of mobile application devices, the user penetration rate of mobile maternal and infant APPs continues to rise. Mobile Internet has become an important channel for users to obtain parenting knowledge and share experience. Many global studies have shown that it is very common for pregnant women to use maternal and infant APPs during pregnancy. More than 50% of pregnant women have downloaded APPs related to pregnancy, with an average of three downloads during the prenatal period (Jayaseelan et al., 2015; Lee & Moon, 2016). Wu (2018) surveyed 400 pregnant women and found that 71% of them use mobile APPs to obtain health information.

In 2017, the National Health and Family Planning Commission issued a notice on the "Thirteenth Five-Year" National Population Health Information Development Plan, proposing to improve various basic business application systems for population health information. The maternal and child health handbook APP is an important application of population health information development. Since July 2017, the Maternal and Child Health Handbook APP mobile platform has been fully promoted and utilized in the Hangzhou area. The health and signing service situations were statistically analysed for the 10 months before and after the application. The results showed that the system management rate of mobile pregnant and parturient women in Hangzhou increased from 71.8% (18478/25735) to 80.2% (21723/27087) during the respective periods (Tao et al., 2019). In early 2016, the National Health and Family Planning Commission issued the "Pilot Work Plan for Maternal and Child Health Handbooks".

According to the national framework requirements for maternal and child health handbooks, it is necessary to combine the four handbooks of pre-pregnancy health care, pregnancy health care, child health care, and planned immunization into one. The handbook also needs to carry government-provided maternal and child health service content, record the process of mothers and children receiving medical health services, record the women's personal experience of pregnancy and childbirth, and the child's growth process. The handbook needs to open functions for service users (Tao et al., 2019).

## **1.2 Research purpose**

The primary objective of this study is to investigate the health information needs of a specific group, pregnant women, regarding the "Maternal and Child Health Handbook" mobile application (APP). The study will analyse the status of the APP's functionality in order to identify any gaps between the services provided and the health information needs of mothers and infants. Ultimately, this study aims to provide development strategies for maternal and infant health related APPs.

## **1.3 Research questions**

This thesis focuses on the information needs and services related to maternal and child health, and resolves the following issues:

- (1) What are the information needs of pregnant women regarding maternal and child health information on mobile APPs?
- (2) What is the status of the functions of the "Maternal and Child Health Handbook" app? What kind of maternal and child health information services are provided online?
- (3) Is there a gap between the information needs and services related to maternal and child health? If so, where does the gap lie?

## 2 LITERATURE REVIEW

This chapter summarized the existing research in the field of healthcare information needs, maternal and infant healthcare information needs, healthcare information services. The purpose of this chapter is to establish the theoretical foundation for this study.

### 2.1 Healthcare information needs

Information needs are an important concept in the research of information behaviour. Taylor proposed the information needs hierarchy theory, which categorizes users' information needs into four different levels: intrinsic needs, perceived needs, formalized needs, and compromised needs (Taylor, 1967). Building upon this, Belkin et al. introduced the concept of "knowledge anomaly," explicitly representing information needs as problems that users cannot accurately articulate (Belkin et al., 1982). Health information originated from the medical field, but with the continuous expansion and deepening of research, it now encompasses various types of information closely related to life and health, including disease knowledge, health knowledge, medical knowledge, health care, nutrition, and health literacy (Meng et al., 2022). Early studies on health information needs primarily utilized questionnaires and interviews, focusing on patients as research subjects to obtain their information needs (Xu, 2013).

With the development of the Internet and information retrieval technologies, an increasing number of Internet users are turning to social question-and-answer websites and online healthcare communities to access health information. Research on health information needs mostly targets specific diseases and populations. Scholars such as Deng et al. and Westbrook et al. respectively studied users' information needs and behaviour regarding hypertension and cervical cancer in social question-and-answer communities (Deng & Liu, 2016; Westbrook & Zhang, 2015). Xu et al. utilized a web survey method to investigate the types of health information needs that the public is most concerned about through research on mobile medical APPs (Xu & Zhao, 2015).

In summary, scholars currently do in-depth theoretical research on information needs. Regarding research methods, existing studies on health information needs mostly employ questionnaire surveys, qualitative analysis, content analysis, text mining,

providing rich theoretical foundations and methodological references for studying maternal and infant health information needs in this paper.

## **2.2 Maternal and infant healthcare information needs**

Maternal and child health information needs refer to the health information needs generated by specific groups such as pregnant women. Scholars have made significant progress in researching maternal and child health information needs. Lagan et al. (2010) demonstrated that most women use online resources to search for pregnancy-related content, particularly social media platforms, information support systems, and e-commerce websites. These resources primarily serve to supplement and extend the basic information provided by healthcare professionals. Through online communities and forums, pregnant women can exchange experiences with other pregnant women and obtain practical advice on childcare and prenatal care. Additionally, e-commerce platforms provide them with convenient ways to purchase maternity clothing, prenatal nutrition products, and other related items, collectively constituting an indispensable part of pregnant women's daily lives.

Scholars mainly conduct qualitative research on maternal and infant healthcare information needs. Kamali S et al. utilized questionnaire surveys and found that when facing illnesses or complications during pregnancy, pregnant women actively seek relevant information (Kamali et al., 2018). Their main areas of concern include fetal care, physiological and psychological complications post-delivery, fetal development and growth processes, as well as prenatal nutrition and specialized examinations. This information assists them in better understanding and coping with various challenges they may encounter during pregnancy. Zeng et al. (2004) conducted a questionnaire survey on the health information needs of late-term pregnant women, identifying the top 10 knowledge needs including fetal movement monitoring, prenatal nutrition, and disease-related knowledge. Gao et al. (2013) conducted research on pregnant women's online information-seeking behaviour through questionnaire interviews and extracted information need themes focusing on different stages of pregnancy such as pregnancy, childbirth, and postpartum recovery.

Recent years, some new research methods have been applied to maternal and infant health information need researches. Liu (2019) studied the health information needs themes and emotional changes characteristics of women during the preconception

period. Ruthven (2019) analysed the information needs of young mothers based on data from posts and inquiries made by users of the UK maternal and child community Net Mums, revealing three major categories of needs: environmental creation, personal social relationships, and child development and health.

Currently, scholars all over the world mainly conduct research on the health information needs of pregnant women using methods such as questionnaire surveys and qualitative interviews, which are subjective. In recent years, a few scholars have used content analysis and text mining methods to study user information needs in maternal and child health-related APPs, but further research is needed in this area.

### **2.3 Healthcare information services**

In the traditional sense, information services can be classified into narrow and broad categories (He, 2006). Narrowly defined information services often refer to the provision of information products and services by relevant professional information service organizations to information users. Broadly defined information services encompass all aspects of information work, including activities such as information collection, integration, storage, processing, analysis, dissemination, and utilization, referring to various information activities that provide and disseminate information to users in the form of products and services (He, 2006). Health information services refer to the provision of health information query, promotion, and dissemination services to the public or specific populations by health-related organizations through various means and measures, aiming to improve public health literacy and overall health levels (Qiang, 2020).

With the development and popularization of mobile Internet technology and smart mobile devices, the way people access information services has changed, including in the field of medical and health information services. An increasing number of users are beginning to use mobile smart devices to access health information. The gap between the usage of online medical industry APPs and PC is gradually widening, and medical industry APPs have become a new way to obtain health information (Xu & Zhao, 2015). Research by Ju & Wang (2018) shows that the ultimate goal of mobile electronic health information services is to deliver the electronic health information needed by relevant information users, that is, to develop information services around the information user group. The information needs and behaviours of information users to some extent

determine the content and mode of mobile electronic health information services. Therefore, analysing the health information needs and behaviours of different information users is the basis and key to continuously improving mobile electronic health information services.

The "Maternal and Child Health Handbook" app is an important project led by the National Health Commission's Maternal and Child Health Division, designed specifically as a mobile health information service platform for pregnant women (Tao et al., 2019). The main purpose of this platform is to provide comprehensive maternal and child health information services to help pregnant women better manage their prenatal health. It not only records various data of mothers and children in the process of healthcare services but also includes women's own experiences and feelings during pregnancy and child-rearing. This platform covers the entire process from preparation before pregnancy, various examinations during pregnancy, the delivery process to postpartum recovery, providing pregnant women with a comprehensive and convenient health management tool to ensure the safety and health of mothers and infants (Tao et al., 2019).

Further research is needed to determine whether the information services provided by this platform can meet users' information needs. Currently, domestic scholars have conducted research on the gap between information needs and services. Lu et al. used content analysis, text mining, and other methods to study the gap between the demand for and the provision of health information services for autism and found discrepancies in economic support and social resource services between the two (Lu et al., 2021).

By reviewing literature, it is found that current research mainly focuses on either maternal and child health information needs or services, and whether there is a gap between the information needs of maternal and child health information users and mobile health information services still requires further study.

### **3 RESEARCH METHODOLOGY**

This chapter illustrates the methodologies used in this research, including the method of literature research, content analysis and text mining methods and how the methodologies are employed to answer the research questions.

#### **3.1 Research Methods**

##### **3.1.1 Literature research method**

Literature review is a widely used method in academic research, which involves collecting, evaluating, analysing, and synthesizing existing research findings and literature materials to establish a comprehensive understanding of a specific research field (Hambleton et al., 1994). Through the literature review method, one can understand and grasp the status of research relevant to the selected topic. Based on the research topic and objectives, relevant literature from domestic and international sources is consulted, read, and analysed to clarify existing research methods, findings, innovations, and shortcomings. This paper searched well-known databases both domestically and internationally, including CNKI Full-text Database, VIP, Web of Science, and others, to retrieve articles related to health information needs, maternal and child health information needs, information services. By studying and understanding the current state of research, it laid a theoretical foundation for the subsequent research work on this topic. Literature review is not only the starting point of a research project but also an important tool for understanding and evaluating the status of a research field. It helps researchers establish an understanding of existing knowledge and researches, avoid duplicating others' work, and provide theoretical basis and background for new research.

##### **3.1.2 Content analysis**

Content analysis is an objective, quantitative, and systematic description and analysis of information content such as text, media content, and language expressions. Its purpose is to extract meaningful information and patterns from these materials (Zhou & Qiu, 2005). This method can help researchers delve into and analyse qualitative materials. Content analysis can be quantitative, such as calculating the frequency of specific words or concepts, or qualitative, such as interpreting and understanding the deeper meaning

of text (Wang, 2009). The basic operational procedure of quantitative content analysis involves using some tool to collect data from representative samples according to a procedure, and finally conducting statistical analysis of the collected data to obtain results (Sun & Bi, 2005). It typically follows the following steps: defining research questions and objectives, selecting samples, determining units of analysis, developing coding schemes, coding and categorizing, analysing and interpreting results, reporting and discussing (Sun & Bi, 2005).

In this study, content analysis was used to analyse the categories of maternal and child health information needs in academic literature, the categories of information services provided by maternal and child health-related APPs, and to compare the categories extracted from both sources. In extracting categories of information services, an iterative coding scheme will be used. In content analysis, iterative coding is a commonly used method for systematically analysing and categorizing data. Iterative coding typically involves multiple reviews and re-examinations of data to refine and improve the classification system or coding scheme. The purpose of this process is to continuously improve classification and coding to ensure that the final analysis is more accurate and reliable (Soares et al., 2022).

### 3.1.3 Text mining method

Text mining is a data mining technique aimed at extracting valuable information and knowledge from text data. It involves the process of extracting potential, user-relevant patterns, knowledge, trends, or relationships from large amounts of unstructured textual information (Chen & Zhang, 2005). The main methods and techniques of text mining include natural language processing, information extraction, topic modelling, sentiment analysis, keyword extraction, text clustering, trend analysis, association rule mining, network analysis, and others. Text mining has wide applications in various fields such as market research, social media analysis, customer service, financial analysis, healthcare, among others. In this study, we intend to use text mining methods to analyse posts in online forums within APPs, supplementing subcategories of maternal and child health information needs.



### 3.1.4 Cluster analysis method

Cluster analysis is a statistical analysis method used to divide observations or samples in a dataset into different groups or categories. The goal of this method is to make members within the same group similar, while members between different groups have significant differences, and these groups are called clusters. Cluster analysis is commonly used in fields such as data mining, pattern recognition, statistical analysis, and machine learning (Lopes et al., 2016). In cluster analysis, samples are grouped by measuring the similarity or distance between them, creating groups with similar characteristics. This helps reveal the potential structure of the dataset, assisting researchers in understanding patterns and relationships in the data. Cluster analysis has many different methods and algorithms, some of the common ones are listed as below:

First, K-means clustering is one of the most common clustering methods. It divides the dataset into K clusters, each represented by the mean of its internal data points. The algorithm optimizes by iteratively moving the centroids of clusters to minimize the distance from each data point to its cluster centroid.

Second, hierarchical clustering organizes data in a tree-like structure (dendrogram), forming a series of nested clusters (Chen et al., 2011). Hierarchical clustering is divided into agglomerative (bottom-up) and divisive (top-down) methods.

Third, DBSCAN (Density-Based Spatial Clustering of Applications with Noise) is a density-based clustering method that can discover clusters of arbitrary shapes. It does not require a predefined number of clusters and can identify noise points (Zhu et al., 2020).

Fourth, Gaussian Mixture Model (GMM) assumes that data is composed of multiple Gaussian distributions, each corresponding to a cluster. It uses a probability model to represent clusters, so the membership of data points is not binary but a probability value (Jiang et al., 2020). In this study, hierarchical clustering method will be adopted, and SPSS tool will be used for clustering analysis of keywords in online forum posts.

### **3.2 Maternal and infant health information needs**

Methodology of Grounded Theory was employed to extract categories and subcategories of maternal and infant health information needs from relevant academic literature. Chinese literature was retrieved from the China National Knowledge Infrastructure (CNKI), while English literature was sourced from the Web of Science.

As pregnant women constitute the primary users of maternal and infant health information, the term "users" is defined as "pregnant women". Irrelevant content was excluded to ensure accurate and targeted search results. The initial search utilized the keyword "pregnant women," along with synonymous terms such as "expectant mother", "gestational women", "maternity" and "postpartum women" to ensure completeness in the retrieval. Subsequently, a second search was conducted using the term "information needs" within the results of the first search. Only literature with research subjects or scopes within China was retained from the search results.

In total, 14 Chinese and 9 English articles were retrieved, spanning from October 2000 to November 2022. Number the retrieved Chinese and English literature, with C01-C14 representing 14 Chinese articles, and E01-E09 representing 9 English articles, as shown in Table 1 and Table 2. While international research on maternal and infant health information needs is extensive, studies in China in this field are relatively limited. Consequently, the number of literature resources suitable for research reference is comparatively modest. The scarcity of domestic attention to this area emphasizes the potential significance of the retrieved literature for informing research in the context of maternal and infant health information needs within China.

Table 1. Summary of Chinese Literature

ID	Title	Research Method
C01	A Study on Hierarchical Multi-Label Classification of User Information Needs in Online Health Communities	Text Mining
C02	Mining User Health Information Needs in Online Maternal and Child Communities: An Empirical Study Based on Mommy Websites	Text Mining
C03	Research on the Platform Design of Maternal and Child Community Based on Service Design Theory	Text Mining
C04	Research on Multi-Level Classification of Maternal and Child Q&A Community Information Based on User Needs	Text Mining
C05	Modeling User Profiles in Online Maternal and Child Communities Based on Information Needs Mining	Text Mining
C06	Analysis of Health Education Knowledge Needs of Pregnant Women in Different Trimesters	Questionnaire Survey
C07	Study on Information Needs of Pregnant and Postpartum Women on Maternal and Child Health Care	Questionnaire Survey
C08	Study on Information Needs of Pregnant and Postpartum Women on Maternal and Child Health Care Based on Target Group Index and Correspondence Analysis	Questionnaire Survey
C09	Survey on the Health Information Needs of 976 Pregnant Women in Dongcheng District, Beijing	Questionnaire Survey
C10	Study on the Health Education Needs of Pregnant Women in Taiyuan City	Questionnaire Survey
C11	Survey and Analysis of Health Information Needs of Pregnant Women during Pregnancy	Questionnaire Survey
C12	Analysis of Health Information Needs of 200 Discharged Women	Questionnaire Survey
C13	Survey and Analysis of Health Information Needs of Inpatient Postpartum Women and Countermeasures	Questionnaire Survey
C14	Study on Information Needs of Preconception Women in Maternal and Child Forums	Content Analysis

Table 2. Summary of English Literature

ID	Title	Research Method
E01	Investigating pregnant women's health information needs during pregnancy on internet platforms	Text Mining
E02	Internet use by Chinese women seeking pregnancy-related information	Questionnaire Survey
E03	A Chinese Survey of Women's Use and Expectation of Pregnancy Applications	Questionnaire Survey
E04	Folic acid awareness and intake among women in areas with high prevalence of neural tube defects in China: a cross-sectional study	Questionnaire Survey
E05	Perceptions of Hong Kong Chinese women toward influenza vaccination during pregnancy	Qualitative Interview
E06	Evaluation of dietary intake of lactating women in China and its potential impact on the health of mothers and infants	Qualitative Interview
E07	Pregnancy-specific anxiety and elective caesarean section in primiparas: A cohort study in China	Questionnaire Survey
E08	Survey on medication information literacy and influencing factors among pregnant Chinese women	Questionnaire Survey
E09	Pregnancy-Related Information Seeking in Online Health Communities: A Qualitative Study	Content Analysis

Following the procedural handling outlined by Grounded Theory (Charmaz, 2014), the collected academic literature underwent systematic coding processes, including open coding, axial coding, and selective coding, progressing iteratively to delineate distinct categories of maternal and infant health information needs. Conceptual concepts and categories were refined, and core categories were identified, exploring relationships between research concepts and categories. Ultimately, this culminated in the formation of a structural diagram depicting the main category relationships concerning maternal and infant health information.

Second, this study systematically analyses information needs from existing academic literature to establish a theoretical foundation and framework of information need categories. However, users in online forums may mention new demands that have not been fully covered in the literature. Therefore, based on the analysis of academic literature, this study conducts text mining on online forums to discover and explore these potential needs further. Ultimately, by integrating the information needs categories obtained from academic literature with those derived from online communities, a more comprehensive framework of maternal and infant health information needs is obtained.

This study selected posts from the online community forums of the "Maternal and Child Health Handbook" mobile application (APP) as the data source. Text mining was employed to analyse the forum posts submitted by users, aiming to complement the subcategories of maternal and child health information needs. The data collection involved web scraping using the Scrapy framework in Python, targeting posts from the "Plaza-Community" module from January 2022 to July 2023. A total of 8,267 posts from the Moments section and 5,490 posts from the Doctor Q&A section were crawled.

Manual data cleaning was conducted to eliminate non-"question" data, including advertisements and experiential sharing posts, from the Moments section. Additionally, posts unrelated to maternal and child health were excluded. The final dataset comprised 2,947 valid posts. Simultaneously, meaningless posts from the Doctor Q&A section were removed, resulting in a total of 2,337 valid posts. The scraping and cleaning process was implemented to ensure the quality and relevance of the collected data for subsequent text mining analysis. This dataset is instrumental in gaining insights into the specific information needs and inquiries of users within the maternal and child health

domain as expressed in the online community forums of the "Maternal and Child Health Handbook" APP.

This study employs cluster analysis to conduct topic coding of maternal and infant health information needs in online communities to complement categories extracted from academic literature. As keyword lists can accurately describe various aspects of information needs, each aspect can be described by many keywords (Ma et al., 2017). Therefore, keyword lists are selected to represent health information needs in online communities. Jieba segmentation is an open-source Chinese segmentation tool widely used in Chinese text processing (Wang et al., 2020). Its unique algorithm and flexibility make it an important tool for processing Chinese text. The design goal of Jieba segmentation is to provide efficient, accurate, and simple Chinese segmentation services to meet the growing demand for natural language processing. The tool achieves precise segmentation of Chinese text based on prefix dictionaries, while also considering applications such as part-of-speech tagging and new word recognition in complex contexts. Word segmentation of posts is accomplished using Jieba in Python, with a custom dictionary uploaded and a stop-word dictionary downloaded from the internet (Sun et al.).

TF-IDF (Term Frequency-Inverse Document Frequency) is a commonly used weighting technique for information retrieval and mining (Li & Zhou, 2015). In this study, the Term Frequency-Inverse Document Frequency (TF-IDF) algorithm is used to select keywords to represent the main content of posts. Then, TF-IDF Top 250 keywords matrices are separately constructed for the "Doctor Q&A" module and the "Friend Circle" module. Hierarchical cluster analysis is conducted using SPSS based on these matrices (Chen et al., 2011). Based on the clustering results, the dendrogram is cut to the desired levels, and the topics of each cluster are named by manually interpreting the keywords (Earle & Hurley, 2015). The topics from both modules are then merged.

During the process of combining and supplementing subcategories, the corresponding results from the forums are integrated into the results obtained from academic literature. The reason is that the lesser interpretability of categories was derived from clustering software compared to those derived from academic literature. Cluster analysis of program software primarily relies on the features of the data itself and similarity measures for grouping, lacking consideration of domain knowledge and

theoretical frameworks. Academic literature typically derives categories through theoretical analysis and expert judgment, based on a thorough understanding of the research subjects and background, thus possessing strong interpretability and credibility.

Finally, based on the analysis of information needs in academic literature and online forums, the categories of maternal and infant health information needs are integrated and summarized. It can be observed that the categories of information needs derived from academic literature and online forums do not have a one-to-one correspondence. Two coders assigned each keyword to the corresponding subcategory based on the literal meaning of the original posts and the underlying needs. If some keywords could not be included in existing subcategories, new subcategories were supplemented. The manual merging work was carried out by two coders, and the inter-coder reliability was calculated using the Holsti formula (Holsti, 1969) as 0.862. Through sufficient negotiation, the two coders reached consensus on the final coding results.

### **3.3 Maternal and infant health information services of APPs**

First, this study analysed maternal and infant health information service in the "Maternal and Child Health Manual" app. Maternal and infant health information services are obtained from articles and video content in the app. The articles and videos in the "Maternal and Child Health Manual" app are primarily concentrated in the "Novice Mommy" module's "Doctor's Three Minutes" section and "Pregnancy Tips" section. A comparison reveals that the content in these two sections does not overlap, allowing for complementary content to enhance the comprehensiveness of collected information services. Using Python, videos and article titles from the "Pregnancy Tips" section, as well as video titles under different categories in the "Doctor's Three Minutes" section toolbar, were scraped. A total of 251 video contents and 57 article contents were obtained. Through manual data cleansing to exclude information service content irrelevant to maternal and infant health, a final count of 247 video contents and 55 article contents was retained, totalling 302 items.

A qualitative content analysis approach is utilized to conduct thematic analysis of the articles and video content collected from the "Maternal and Child Health Manual" app through manual coding. Website navigation refers to the organization and disclosure of online information resources. In this research, the categories of

information services are extracted from the navigation bar of the "Doctor's Three Minutes" section.

In obstetrics and gynaecology studies, knowledge about pregnancy is systematically classified, including aspects such as the normal process of pregnancy, prenatal examinations and health measures, abnormal pregnancy conditions, common symptoms during pregnancy, and potential complications. Therefore, when extracting subcategories and tertiary categories of information services, the classification of knowledge in obstetrics and gynaecology is referenced to construct the initial coding scheme for maternal and infant health information services. Based on this scheme, the initial coding scheme is iterated until no new themes emerge. The process of thematic coding for information services is illustrated in Figure 1.

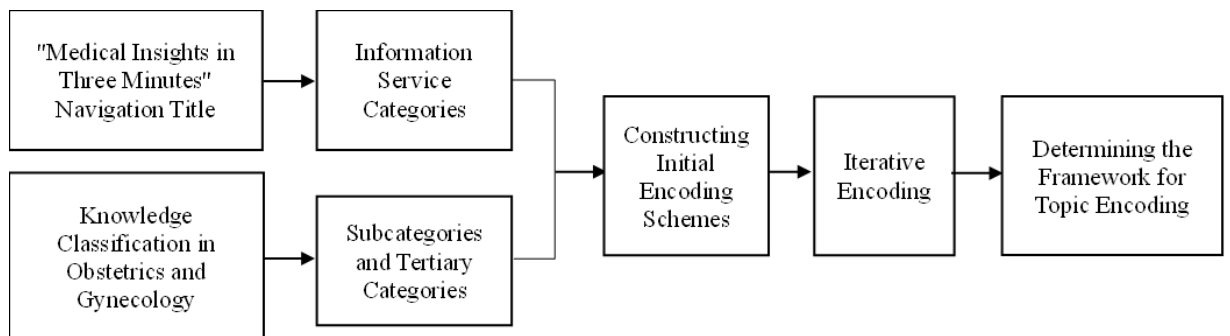


Figure 1. Process Diagram of Information Service Theme Coding

In this study, the coding was conducted based on the titles of videos or articles. Initially, after achieving a consensus understanding of the initial coding scheme, two coders categorized the video titles from the "Three Minutes of Doctor's Voice" section and the video and article titles from the "Pregnancy Tips" section. In cases where the categorization of titles was inconsistent, the two coders engaged in thorough discussions to reach a consensus and subsequently revised and supplemented the coding scheme.

During the first iteration, adjustments were made to the categories and subcategories of the initial scheme. Due to content overlap between the "Childcare" and "Baby" sections in the "Three Minutes of Doctor's Voice" section, the redundant content was removed, and the content under the "Baby" category was merged into the "Childcare" category. After categorizing all video and article content, categories such as "Music and Dance," "Games and Toys," and "Early Education and Intelligence" had no

corresponding video or article content and were thus eliminated. Additionally, "Habit Formation" falls under the category of "Childcare"; therefore, these two navigation categories were included as subcategories under the "Childcare" category. Furthermore, although there were no categories related to childbirth in the navigation bar of the "Three Minutes of Doctor's Voice" section, there were several related information service contents in the "Pregnancy Tips" section.

Consequently, the category "Postpartum Recovery" was renamed as "Childbirth and Postpartum Recovery." In addition, the subcategories "daily health care" and "disease prevention" can be merged into one category because they both focus on promoting maternal health and preventing illnesses, with significant overlap between them. During pregnancy, proper daily health care measures can effectively prevent diseases, so merging them together would facilitate providing comprehensive information support.

In the second iteration, no adjustments were needed for the health information service categories, but titles categorized under "Other" were organized and supplemented into subcategories. Upon analysis of titles categorized under "Other," it was found that they also provided information services related to family support. Ultimately, the coding scheme for mother and infant health information services was formed, as shown in Table 3. The reliability between coders was calculated using the Holsti formula (Holsti, 1969), yielding a result of 0.87.



Table 3. Coding Scheme for Mother and Infant Health Information Service Themes

Category	Subcategory	Subclass	Definition	
Preconception Guide	Preconception Knowledge and Precautions	Preconception Methods and Pregnancy Confirmation	Various measures and methods to prepare for pregnancy, and how to confirm pregnancy	
		Gynecological Diseases and Fertility	How gynecological health issues affect women's fertility	
Pregnancy Encyclopedia	Physiological Conditions and Symptoms	Changes and Symptoms During Pregnancy	Observable bodily changes and physiological symptoms	
		Common Symptoms During Pregnancy and Management	Common symptoms such as constipation, cramps, edema, backache, etc., and their management	
		Pregnancy Complications	Pregnancy-induced hypertension, intrahepatic cholestasis of pregnancy, miscarriage, preterm birth	
		Pregnancy Complicated with Medical Conditions	Diabetes, viral hepatitis, thyroid disorders, etc.	
	Daily Health Care and Disease Prevention	Pregnancy Checkup	Medication Selection and Usage during Pregnancy	Medication selection for pregnant women and its impact on the fetus
			Pregnancy Weight Management	Management and methods for pregnancy weight
			Pregnancy Health Monitoring	Self-monitoring during pregnancy
			Handling Special Situations	Dealing with accidents such as being bitten by pets
	Diet and Nutrition	Fetal Development	Establishment of Medical Records	Strategies for Establishing Medical Records
			Related to Prenatal Checkups	Prenatal checkups and precautions
			Analysis of Prenatal Test Indicators	Interpretation of various prenatal test report indicators
	Diet and Nutrition	Fetal Development	Dietary Advice and Taboos for Pregnant Women	Dietary precautions and taboos during pregnancy
			Specific Dietary Management	Dietary management for conditions like diabetes, chronic gastritis, etc.
			Nutrient Intake and Supplementation for Pregnant Women	Intake and supplementation of nutritional supplements
Diet and Nutrition	Fetal Development	Fetal Movement Monitoring	Fetal movement counting and factors affecting fetal movement	
		Fetal Heart	Normal range and applicability	

Category	Subcategory	Subclass	Definition
		Monitoring	of fetal heart monitoring
		Fetal Abnormalities and Abnormalities in Fetal Appendages	Intrauterine growth restriction, macrosomia, placenta previa, placental abruption, etc.
		Fetal Monitoring	Monitoring fetal position and umbilical cord around the neck
		Weight Prediction and Management	Fetal weight prediction and management
		Prenatal Education	Methods and timing of prenatal education
	Daily Life	Daily Care for Pregnant Women	Daily life care for pregnant women
		Lifestyle Habits and Daily Management	Pregnancy lifestyle habits and management of daily necessities
		Environmental and Activity Safety Guidance	Safety precautions for daily living environment and activities during pregnancy
		Pregnancy Work	Precautions during pregnancy work
		Pregnancy Exercise	Precautions and guidance for pregnancy exercise
		Psychological Health and Family Relationships during Pregnancy	Psychological health during pregnancy and handling family relationships
		Sleep	Guidance on sleep during pregnancy
Childbirth and Postpartum Recovery	Labor Knowledge	Labor symptoms and management	Recognition and coping with labor symptoms
	Pre-labor Preparations	Labor precautions	Labor precautions such as Lamaze breathing
		Abnormal Labor	Abnormal labor such as postpartum hemorrhage
		Choice of Delivery Method	Selection of different delivery methods
		Pre-labor Items Preparation	Hospital admission checklist
		Labor Pain Relief	Options for labor pain relief
	Postpartum Care	Confinement Customs	Explanation of confinement customs
		Postpartum Diet and Nutrition	Postpartum dietary issues
		Postpartum Taboos	Postpartum taboos
		Postpartum Care and Recovery	Postpartum care and recovery
Childcare	Feeding and Care	Daily care for infants	Infants care

Category	Subcategory	Subclass	Definition
		Breastfeeding	Correct guidance for breastfeeding
		Infant Diet and Digestion	Precautions for infant diet
	Physiological Conditions and Prevention	Infant Development and Growth	Issues related to infant development and growth
		Infant Illnesses and Treatment	Common infant illnesses and treatment methods
		Infant Illness Care and Precautions	Care and precautions during infant illness
	Parenting Education	Early Education and Intelligence	Early education and intelligence for infants
		Formation of Habits	Cultivating habits such as infant sleep
Other	Others	Family Support	Support from family during the childbirth process

Second, to obtain a comprehensive overview of the information services provided by maternal and child health-related (MCH) APPs, this study conducted an analysis of the "Maternal and Child Health Handbook" app and selected the top three APPs in terms of user reviews from the application marketplace for additional analysis of information services. When selecting MCH APPs, the search term "maternal and child health" was used for retrieval. Based on the number of user ratings, the top three ranked APPs were "Meiyou," "Babytree Pregnancy," and " Mom Forum Pregnancy." These APPs provide information and services related to maternal and child health. While these applications may not encompass all MCH APPs, they cover the most frequently used APPs by users.

Website navigation is the process of organizing and disclosing internet information resources (Gao & Yang, 2002). Information service categories were extracted from the navigation bar of the app, and subcategories and tertiary categories were extracted from their subordinate categories, respectively. Due to the diversity of APPs and the lack of a unified knowledge structure, there were some differences in the navigation and classification of each app. Therefore, after integrating different category expressions with the same meaning, they were allocated according to the frequency of occurrence of each category. If a category can always be found in the first-level category of website navigation, it should naturally be classified as a first-level category; otherwise, it should be considered a subcategory of the most frequently appearing higher-level category. This process was conducted by two coders, and the reliability between the two coders

calculated using the Holsti formula (Holsti, 1969) was 0.88. After sufficient discussion, the two coders reached a consensus on the issues where differences occurred.

## 4 EMPIRICAL RESULTS OF THE RESEARCH

### 4.1 Information needs from documents

#### 4.1.1 Open coding

Open coding serves as the foundation for constructing theoretical models and involves the process by which researchers abstract phenomena, extract concepts, and determine categories from raw data. At this stage, it is imperative to remain faithful to the original data and construct a concise and precise preliminary coding system (Ke et al., 2014). Therefore, throughout the implementation process, this study maintained an open-minded approach, conducting a meticulous analysis of retrieved academic literature, scrutinizing every word and sentence, and engaging in iterative comparisons between concepts. Fourteen Chinese literature (C01-C14) and five English literature (E01-E05) were selected for open coding, while the remaining four English literature (E06-E09) were reserved for theoretical saturation testing.

For literature categorized based on information needs obtained through text mining, key concepts, keywords, or phrases were extracted from each subcategory. Subsequently, these extracted concepts were recombined and classified to form more abstract and comprehensive categories. Through repeated cross-referencing, comparison, and organization, a total of 79 initial concepts were distilled in this study and encoded in the form of "a" followed by a numerical value. These initial concepts were grouped and classified into 62 preliminary categories to facilitate a more systematic analysis. The process of open coding is illustrated in Table 4.

Table 4. Process of Open Coding

Category	Partial Representative Keywords/Sentences	Document Number	Initial Concept
Preconception Methods and Pregnancy Status	Preconception Methods	C05	Preconception Methods (a1)
	Infertility	C14	
	Pregnancy Confirmation	C05, E01	Pregnancy Confirmation (a2)
Prenatal Knowledge	Prenatal Knowledge	C01	Prenatal Knowledge (a3)
Prenatal Knowledge	Preconception Medication	C01	Preconception Medication (a4)
	Body Adjustment and Lifestyle	C04	
Body Adjustment and	Body Adjustment and	C01	Body Adjustment and

<b>Category</b>	<b>Partial Representative Keywords/Sentences</b>	<b>Document Number</b>	<b>Initial Concept</b>
Lifestyle	Lifestyle		Lifestyle (a5)
Physiological Symptoms and Management during Pregnancy	Physiological Changes and Symptoms during Pregnancy	C02, C06, E01	Physiological Changes and Symptoms during Pregnancy and Management (a6)
	Relief of Common Discomforts during Pregnancy	C08,C09,C10	
	Symptoms and treatment of mild discomfort during pregnancy	C01, C04	Common Discomforts during Pregnancy and Treatment (a7)
Abnormal Pregnancy and Complications	Miscarriage	C01, C04, C05	Miscarriage (a8)
	Threatened Miscarriage	E01	
	Abnormal Pregnancy	C02	Pregnancy Complications and Complications (a9)
	Pregnancy Complications	C02, E02	
	Major Pregnancy Complications and Treatment	C01, C04	
Dietary Advice and Taboos	Dietary Advice and Taboos	C01	Dietary Advice and Taboos (a10)
	Dietary Taboos	C04	
	Dietary Habits	C14	
	Prenatal Diet	E01	
Nutritional Supplementation	Maternal Nutrition Intake and Supplementation	C01	Nutritional Supplementation during Pregnancy (a11)
	Pregnancy Nutrition	C08, C09, C10	
	Only 15% of women are familiar with all core information about folic acid	E04	Folic Acid Supplementation (a12)
Psychological Care	Psychological Care	C02	Psychological Care (a13)
	Psychological Care during Pregnancy	C11	
	Psychological Care during Pregnancy and Childbirth	C08, C09, C10	
	Pregnancy-related Psychological Mood	C01	
Physiological Health	Prevention of Common Diseases during Pregnancy	C06	Disease Prevention (a14)
	Disease Prevention	C02	
	Confusion about the Safety and Efficacy of Influenza Vaccine	E05	Vaccination (a15)

<b>Category</b>	<b>Partial Representative Keywords/Sentences</b>	<b>Document Number</b>	<b>Initial Concept</b>
	Breast Health Knowledge	C11	Breast Health (a16)
Medication Selection and Usage during Pregnancy	Medication Selection during Pregnancy	C01	Medication Selection (a17)
	Selection of Medications and Health Products	C14	
	Medication Usage	C01	Medication Usage (a18)
	Medication Use during Pregnancy and Avoidance of Harmful Substances	C06	
Pregnancy Weight Management	Pregnancy Weight Management	C04	Pregnancy Weight Management (a19)
	Pregnancy Weight Management	E01	
Self-monitoring during Pregnancy	Self-monitoring Methods during Pregnancy	C07	Self-monitoring Methods during Pregnancy (a20)
Pregnancy File Creation	Pregnancy File Creation	C04, C05	Pregnancy File Creation (a21)
Prenatal Examination Related	Prenatal Examination Selection	C01, C04	Selection of Prenatal Examinations (a22)
	Selection and Necessity of Prenatal Examinations	C02	
	Free Examination Items	C02	Free Examination Items (a23)
Prenatal Examination Process and Precautions	Prenatal Examination Process and Precautions	C01, C02, C04	Prenatal Examination Process and Precautions (a24)
Analysis of Prenatal Examination Indicators	Analysis of Prenatal Examination Indicators	C01	Analysis of Prenatal Examination Indicators (a25)
	Pregnancy test results	C02	
Timing of Prenatal Examinations	Timing of Prenatal Examinations	C01, C02, C04	Timing of Prenatal Examinations (a26)
	Reminder for Prenatal Examinations	E03	
Prenatal Examination Costs	Prenatal Examination Costs	C01, C04	Prenatal Examination Costs (a27)
Selection of Prenatal Examination Institutions or Locations	Selection of Prenatal Examination Institutions or Locations	C01	Selection of Prenatal Examination Institutions or Locations (a28)
	Selection of Examination Locations	C04	
	Selection of Examination Locations	C02	
Naming the Fetus	Naming the Fetus	C01, C04	Naming the Fetus (a29)
Calculation of Gestational Age	Calculation of Gestational Age	C01, C04, E01	Calculation of Gestational Age (a30)

<b>Category</b>	<b>Partial Representative Keywords/Sentences</b>	<b>Document Number</b>	<b>Initial Concept</b>
Monitoring Fetal Movements	Monitoring Fetal Movements	C01, C04, E01	Monitoring Fetal Movements (a31)
	Methods for Self-monitoring Fetal Movements	C11	
Fetal Heart Monitoring	Fetal Heart Monitoring	C01, C04	Fetal Heart Monitoring (a32)
	Methods for Listening to Fetal Heart Sounds	C11	
Normal Fetal Developmental Characteristics and Precautions	Normal Fetal Developmental Characteristics and Precautions	C01, C04	Normal Fetal Developmental Characteristics and Precautions (a33)
	Fetal Development Status	C07, E03	
Gender Prediction	Gender Prediction	C01, C04	Gender Prediction (a34)
	Child Gender	C14, E01	
Prenatal Education	Prenatal Education	C01,C02,C05, C08,C09,C10	Prenatal Education (a35)
	Prenatal Education Music	C03	
	Related Prenatal Education Knowledge	C06	
Maternal Daily Care	Maternal Daily Care	C01	Maternal Daily Care (a36)
	Harmful Substances and Precautions	C02	
Selection of Maternal Supplies	Selection of Maternal Supplies	C01	Selection of Maternal Supplies (a37)
	Procurement of Supplies	C04	
Work during Pregnancy	Work during Pregnancy	C01,C04	Work during Pregnancy (a38)
	Work and Maternity Leave	C05	
Exercise during Pregnancy	Exercise during Pregnancy	C01,C04,E02	Exercise during Pregnancy (a39)
	Exercise and Fitness	C02	
Maternal Leisure Activities	Maternal Leisure Activities	C01,C04	Maternal Leisure Activities (a40)
Sleep and Fetal Dreams	Sleep and Fetal Dreams	C01	Sleep and Fetal Dreams (a41)
	Sleep Quality	C04,E01	
	Fetal Dreams	C04	
Symptoms and Coping during Labor	Symptoms and Coping during Labor	C01	Symptoms and Coping during Labor (a42)
	Recognition and Treatment of Labor Symptoms	C04	
Delivery Techniques	Labor Precautions	C01,C06	Labor Precautions (a43)



<b>Category</b>	<b>Partial Representative Keywords/Sentences</b>	<b>Document Number</b>	<b>Initial Concept</b>
and Methods	Issues to Note during Delivery	C13	
	Delivery Techniques and Methods	C02	Delivery Techniques (a44)
	Cooperation Techniques during Delivery	C13	
	Labor Process	C02	Labor Knowledge (a45)
	Labor Knowledge	C08,C09,C10	
Induction of Labor	Induction of Labor	C01,C04	Induction of Labor (a46)
Selection of Delivery Method and Impact	Selection of Delivery Method	C01,C04,C06,E02	Selection of Delivery Method and Impact (a47)
	Selection of Delivery Method and Impact	C02	
Preparation of Delivery Items	Preparation of Delivery Items	C01	Preparation of Delivery Items (a48)
	Selection of Hospital and Medical Staff	C04	
Selection of Hospital and Medical Staff	Selection of Hospital and Medical Staff	C01	Selection of Hospital and Medical Staff (a49)
	Selection of Hospital and Doctors	C02,E02	
Delivery Expenses	Delivery Expenses	C01,C04	Delivery Expenses (a50)
	Know the Daily Hospitalization Costs	C11	
Epidural Analgesia	Epidural Analgesia	C06	Epidural Analgesia (a51)
	Methods to Reduce Labor Pain	C08,C09,C10	
	Preparation for Pain Relief during Delivery	C11	
Selection of Postpartum Institutions	Selection of Postpartum Institutions	C01	Selection of Postpartum Institutions (a52)
	Postpartum Services	C02	
Postpartum Diet and Nutrition	Postpartum Diet and Nutrition	C02	Postpartum Diet and Nutrition (a53)
	Postpartum Nutritional Guidance	C12,E02	
Postpartum Taboos and Precautions	Postpartum Taboos and Precautions	C02	Postpartum Taboos and Precautions (a54)
	Postpartum Recovery	C01	Postpartum Recovery (a55)
Postpartum Recovery	Postpartum Recovery	C02,C05,E02	Postpartum Recovery (a56)
	Postpartum Recovery Guidance	C12	

Category	Partial Representative Keywords/Sentences	Document Number	Initial Concept
	Postpartum Repair Methods	C07	
	Confinement in childbirth	C05	Confinement in childbirth (a57)
	Scientific Confinement in childbirth	C06	
Infant Daily Care	Infant Daily Care	C01,C06,E02	Infant Daily Care (a58)
Selection of Infant Medications	Selection of Infant Medications	C01	Selection of Infant Medications (a59)
Selection of Infant Supplies	Selection of Infant Supplies	C01	Selection of Infant Supplies (a60)
	Newborn Supplies	C02	
Breastfeeding Diet	Breastfeeding Diet	C01	Breastfeeding Diet (a61)
	Breastfeeding	C08,C09,C10,E04	Breastfeeding (a62)
	Demand for Knowledge and Skills about Breastfeeding	C06,C12,C13	
Abnormal Infant Behaviors and Coping	Abnormal Infant Behaviors and Coping	C01	Abnormal Infant Behaviors and Coping (a63)
Infant Illness and Treatment	Infant Illness and Treatment	C01	Infant Illness and Treatment (a64)
	Prevention and Treatment of Neonatal Diseases	C02	Prevention and Treatment of Neonatal Diseases (a65)
	Prevention of common infant diseases	C11	
Care and Precautions during Infant Illness	Care and Precautions during Infant Illness	C01	Care and Precautions during Infant Illness (a66)
Parenting Knowledge and Experience Sharing	Parenting Knowledge and Experience Sharing	C01	Parenting Knowledge and Experience Sharing (a67)
	Rearing and Education	C01	Early Childhood Education (a68)
	Baby Education	C03	
	Early Childhood Education	C06	
Selection of Infant Care Institutions and Physicians	Selection of Infant Care Institutions and Physicians	C01	Selection of Infant Care Institutions and Physicians (a69)
Sharing Experiences	Sharing Experiences	C01,E01	Sharing Experiences (a70)
	Posting, Community Viewing	C03	
Seeking Social Support	Seeking Social Support	C01,C04	Seeking Social Support (a71)
Seeking Similar Experiences	Seeking Similar Experiences	C01	Seeking Similar Experiences (a72)

Category	Partial Representative Keywords/Sentences	Document Number	Initial Concept
	Following Users in Similar Stages	C03	
	Seeking Companions with Similar Experiences	C04	
Spousal and Family Relationships	Family Relationships	C02	Spousal and Family Relationships (a73)
	Marital Relationships	C04	
	Family Relationships	C04	
	Making Friends during Pregnancy	C02	Making Friends (a74)
	Joining Mom WeChat Groups	C03	
Social Security Policies and Processes	Social Security Policies and Processes	C02	Social Security Policies and Processes (a75)
Maternity Policies and Insurance	Maternity Policies	C02	Maternity Policies and Insurance (a76)
	Maternity Insurance	C05, C08, C09, C10	
Procedures and Documents for Childbirth	Procedures and Documents for Childbirth	C02	Procedures and Documents for Childbirth (a77)
Maternity Leave and Labor Protection	Maternity Leave and Labor Protection	C02	Maternity Leave and Labor Protection (a78)
	Pregnancy Leave	C04, C05	Maternity Leave (a79)

#### 4.1.2 Axial coding

Axial coding involves the reclassification and refinement of initial categories formed during open coding, aiming to develop categories with richer, more precise, and complex meanings to better explain the research phenomenon. By analysing the interrelationships and logical connections between initial categories, they can be reorganized to form more abstract core categories. Through iterative comparisons and logical selection of the 62 categories formed during open coding, categories belonging to the same type were grouped and clustered.

This process culminated in the formation of 15 core categories: "Preconception Knowledge and Precautions", "Pregnancy Physiological Status and Symptoms", "Diet and Nutrition", "Daily Healthcare and Disease Prevention", "Prenatal Examination", "Fetal Development", "Daily Life", "Pre-delivery Preparation", "Postpartum Recovery", "Infant Care and Nursing", "Infant Physiological Status and Prevention", "Infant

Education", "Interpersonal and Social Relationships", "Fertility Policy and Social Security" and "Maternity Leave and Labor Protection". These core categories were then classified into six dimensions: "Preconception Information", "Pregnancy Information", "Labor and Postpartum Information", "Infant Health and Parenting Information", "Emotional Support", and "Policy and System". The specific process of axial coding is detailed in Table 5.

Table 5. List of Axial Coding

<b>Dimension</b>	<b>Core Category</b>	<b>Category</b>	<b>Category Content</b>
Preconception Information	Preconception Knowledge and Precautions	Preconception Methods and Pregnancy Status	Measures taken by couples before planning pregnancy, monitoring pregnancy indicators, and testing
		Eugenics Knowledge	Concerns of couples before and during pregnancy about genetics and embryo health
		Preconception Medication	Use of medications to support preconception and pregnancy
		Body Adjustment and Lifestyle	Lifestyle adjustments made by couples during preconception to avoid exposure to pregnancy risks
Pregnancy Information	Pregnancy Physiological Status and Symptoms	Physiological Changes and Symptoms during Pregnancy	Physiological symptoms, changes, discomforts during pregnancy, and methods to alleviate them
		Abnormal Pregnancy and Complications	Possible abnormal conditions during pregnancy, such as miscarriage, preterm birth, and potential complications like hypertension, diabetes, etc.
	Diet and Nutrition	Dietary Advice and Taboos	Guidance on dietary choices and foods to avoid
		Nutritional Supplementation	Nutrients needed during pregnancy, such as vitamins, folic acid, etc.
	Daily Healthcare and Disease Prevention	Physiological Healthcare	Prevention of diseases and vaccination during pregnancy, breast health
		Psychological Healthcare	Management of emotions, psychological support, and stress management during pregnancy
		Medication Selection and Usage during Pregnancy	Safe medication use, proper dosage management, medication information
		Pregnancy Weight Management	Methods for managing weight during pregnancy
		Self-monitoring during Pregnancy	Methods for self-monitoring during pregnancy
	Prenatal	Prenatal Registration	Registration and application of

<b>Dimension</b>	<b>Core Category</b>	<b>Category</b>	<b>Category Content</b>
	Examination	and Documentation	relevant records in early pregnancy
		Prenatal Examination Related	Selection and necessity of regular medical examinations during pregnancy
		Prenatal Examination Process and Precautions	Process and precautions of prenatal examinations
		Prenatal Examination Indicators Analysis	Interpretation and assessment of various indicators during prenatal examinations
		Timing of Prenatal Examinations	Timing for prenatal examinations
		Prenatal Examination Costs	Costs associated with prenatal examinations
		Selection of Prenatal Examination Institutions or Locations	Considerations for selecting medical institutions or locations for prenatal examinations
	Fetal Development	Naming the Fetus	Choosing appropriate names for the unborn child
		Calculation of Gestational Age	Calculating pregnancy cycles and estimated delivery dates
		Monitoring Fetal Movements	Observing and recording fetal movements in the womb
		Fetal Heart Monitoring	Process of monitoring fetal heartbeats using medical devices
		Normal Fetal Developmental Characteristics and Precautions	Understanding normal fetal development characteristics and areas requiring attention
		Gender Prediction	Attempting to predict the gender of the fetus
		Prenatal Education	Methods, timing, and potential impacts of prenatal education
	Daily Life	Maternal Daily Care	Daily care for pregnant women and avoiding harmful environments and activities
		Selection of Maternal Supplies	Choosing relevant supplies needed during pregnancy
		Work during Pregnancy	Work arrangements and adaptation measures in the workplace during pregnancy
		Exercise during Pregnancy	Moderate physical exercise for pregnant women
		Maternal Leisure Activities	Various activities beneficial for physical and mental health
		Sleep and Fetal Dreams	Quality of sleep for pregnant women and potential fetal dreams
Labor and	Pre-delivery	Recognition and	Symptoms experienced by women

<b>Dimension</b>	<b>Core Category</b>	<b>Category</b>	<b>Category Content</b>
Postpartum Information	Preparation	Management of Labor Symptoms	approaching childbirth and effective coping measures
		Delivery Techniques and Precautions	Techniques and precautions during childbirth, including breathing, exertion, positions, etc.
		Induction of Labor	Indications, methods, risks, and effects of labor induction
		Selection of Delivery Method and Impact	Comparison of natural childbirth and cesarean section, selection criteria, and potential impacts
		Preparation for Labor	Preparation of items required during labor
		Hospital and Medical Staff Selection	Selection of delivery rooms, hospitals, and professional medical staff
		Delivery Expenses Epidural Analgesia	Costs incurred during childbirth Use of medications or other techniques to alleviate pain during childbirth
	Postpartum Recovery	Selection of Confinement Institutions	Choosing appropriate confinement institutions
		Postpartum Diet and Nutrition	Dietary arrangements for new mothers during the postpartum period
		Postpartum Taboos and Precautions Postpartum Recovery	Special taboos and precautions to follow postpartum Comprehensive physical and psychological recovery processes after childbirth
Infant Health and Parenting Information	Infant Care and Nursing	Infant Daily Care	Daily care activities for infants, such as bathing, diaper changing, etc.
		Selection of Infant Medications	Selection and use of medications for infants
		Selection of Infant Supplies	Choosing appropriate supplies for infants as they grow
		Breastfeeding Diet	Breastfeeding methods and dietary advice for infants
	Infant Physiological Status and Prevention	Abnormal Infant Behaviors and Coping	Abnormal Infant Behaviors and Coping
		Infant Illness and Treatment	Common infant illnesses and corresponding treatment methods
		Infant Illness Care and Precautions	Care and specific points to note when infants are sick
	Infant Education	Parenting Knowledge and Experience Sharing	Sharing information, skills, and experiences of raising children
		Selection of Infant Care	Selecting appropriate childcare

<b>Dimension</b>	<b>Core Category</b>	<b>Category</b>	<b>Category Content</b>
Emotional Support	Interpersonal and Social Relationships	Institutions and Physicians	institutions and medical professionals
		Sharing Experiences	Parents or other caregivers sharing their practical experiences in parenting
		Seeking Social Support	Seeking support networks within the community
		Seeking Similar Experiences	Finding people with similar parenting experiences
Policy and System	Fertility Policy and Social Security	Spousal and Family Relationships	Spousal and Family Relationships
		Social Security Policies and Procedures	Social insurance policies related to fertility
		Fertility Policies and Insurance	National or regional fertility policies and fertility insurance
	Maternity Leave and Labor Protection	Procedures and Document Processing for Fertility	Completing relevant procedures for fertility
		Maternity Leave and Labor Protection	Understanding and enjoying corresponding maternity leave policies

#### 4.1.3 Selective coding

Selective coding builds upon axial coding by further refining, synthesizing, merging, and refining core categories identified during axial coding. It aims to identify core categories and establish systematic connections between these core categories and other categories. Core categories need to encapsulate all concepts and categories at a high level, concentrating them within a theoretical framework, and depicting the overall behavioural phenomenon in a narrative form, revealing the main thread of the research problem. Based on the 15 core categories obtained from axial coding, a thorough refinement and analysis of their classification and dimensions were conducted, ultimately identifying "Maternal Health Information Needs" as the core category. By delving into the relationships between categories, a structural diagram of core categories, as shown in Figure 2, was developed. Maternal health information needs can be divided into preconception, pregnancy, delivery and postpartum, as well as information needs related to infant health and parenting, emotional support throughout the entire pregnancy and childbirth process, and information needs related to policy systems.

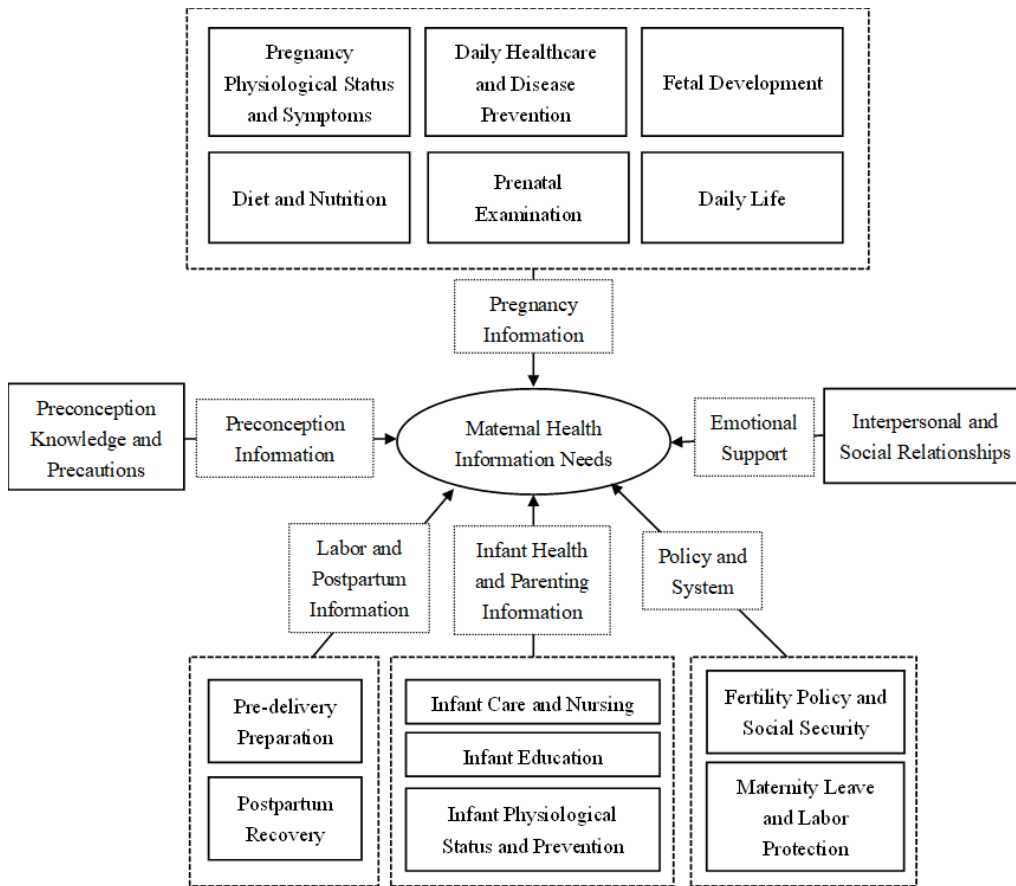


Figure 2. Structure Diagram of Core Categories

#### 4.1.4 Theoretical saturation test

Following the completion of coding, it is necessary to conduct a theoretical saturation test to validate the comprehensiveness of concepts or categories extracted from the literature. This test determines whether it is possible to induce and refine new concepts and categories. If no new concepts or categories can be induced, the theory is considered saturated. In this study, the remaining four English articles (E06-E09) were organized and analysed according to the steps of Grounded Theory coding, and no new concepts or categories were generated. Therefore, this study considers the theoretical saturation test to be successful.

The main categories of maternal and infant health information needs and their corresponding literature frequencies are shown in Figure 3. The extraction results indicate that maternal and infant health information needs are diverse and cover a wide range, but the distribution of needs is uneven. Pregnant and postpartum women not only focus on pregnancy and childbirth itself, such as relevant professional knowledge,



postpartum recovery, and newborn care, but also have high demands for addressing their own emotional issues and receiving emotional support.

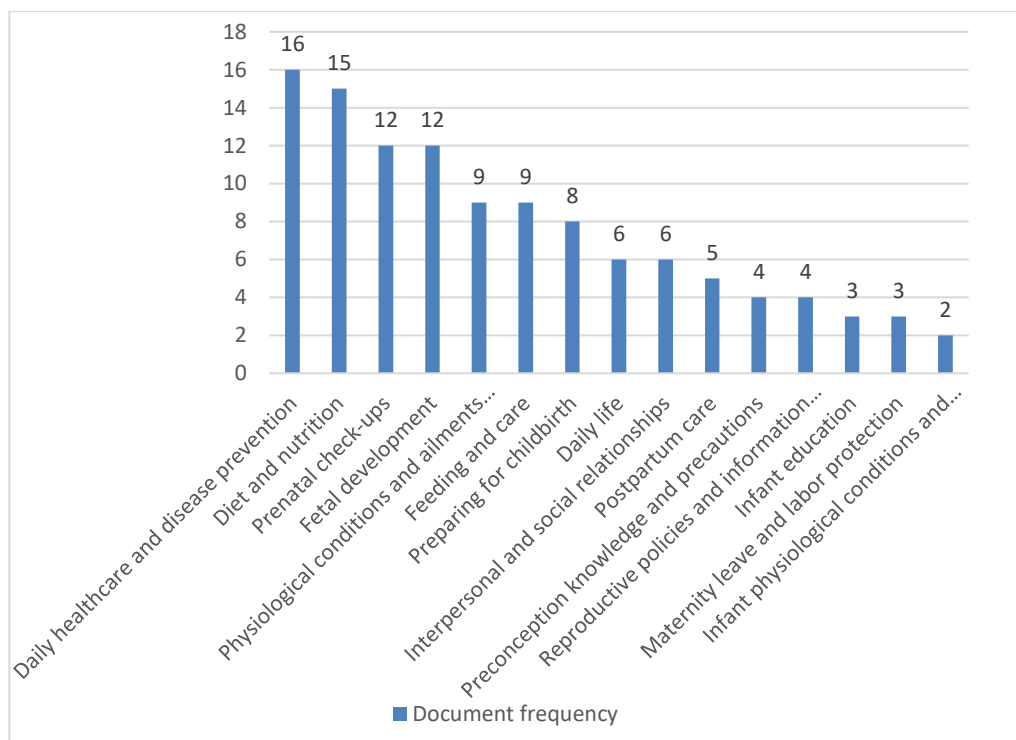


Figure 3. Literature Frequencies Corresponding to Main Categories of Information Needs in Academic Literature

#### 4.2 Information needs from online forum

The top 10 TF-IDF keywords from the "Doctor Q&A" module of the online community forum in the "Maternal and Child Health Manual" app are shown in Table 6, and the top 10 TF-IDF keywords from the "Friend Circle" module are shown in Table 7. Figure 3 and Figure 4 display the clusters of 10 keywords from the 250 keywords in the "Doctor Q&A" module and the 12 clusters from the "Friend Circle" module, respectively, including keyword counts. There are 38 identical keywords in the same categories in both modules, resulting in 462 unique keywords after removing duplicates. Similar to the results of information needs in academic literature, the distribution of information needs in online forums is also uneven.

Table 6. Top 10 TF-IDF Keywords in the "Doctor Q&amp;A" Module

Keyword	TF-IDF	Keyword	TF-IDF
Physical examination	104.11666	Appointment	44.85012
Hospital	75.39007	Community	43.73691
Examination	73.37510	Folic acid	33.87636
Report	70.14949	Fasting	29.81822
Vaccine	49.61702	Formula	27.15108

Table 7. Top 10 TF-IDF Keywords in the "Friend Circle" Module

Keyword	TF-IDF	Keyword	TF-IDF
Hospital	66.54224	Recommend	33.38173
Pregnancy	58.58686	Boy	32.15678
Examination	46.60622	Sleep	31.08074
Formula	40.06707	Girl	29.84870
Fetal movement	38.36062	Ultrasound	26.15524

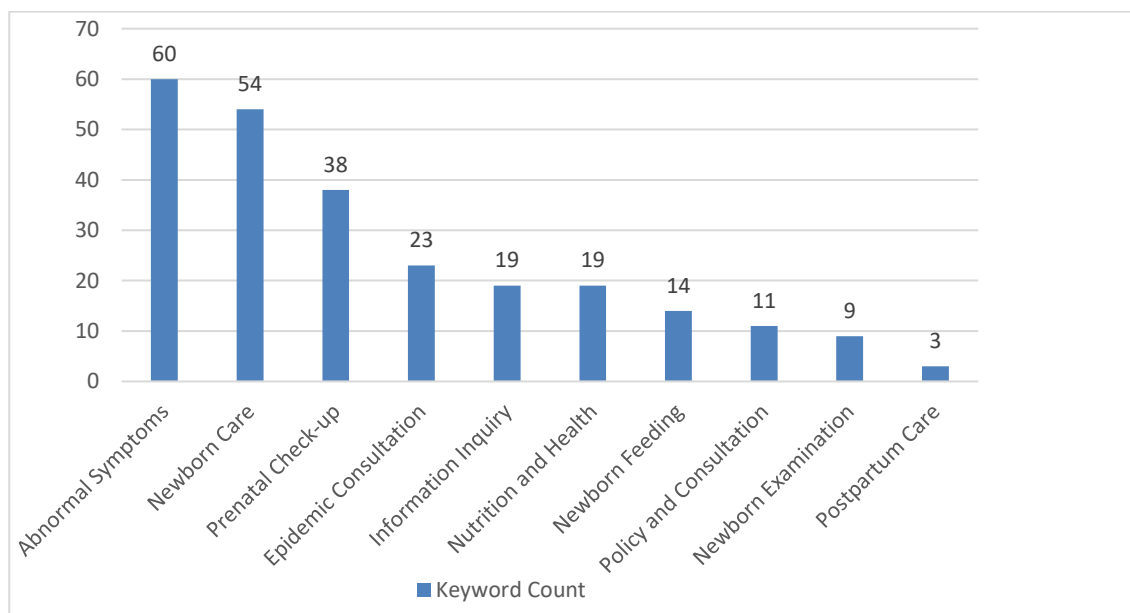


Figure 4. Keyword Clusters in the "Doctor Q&amp;A" Module of the Forum

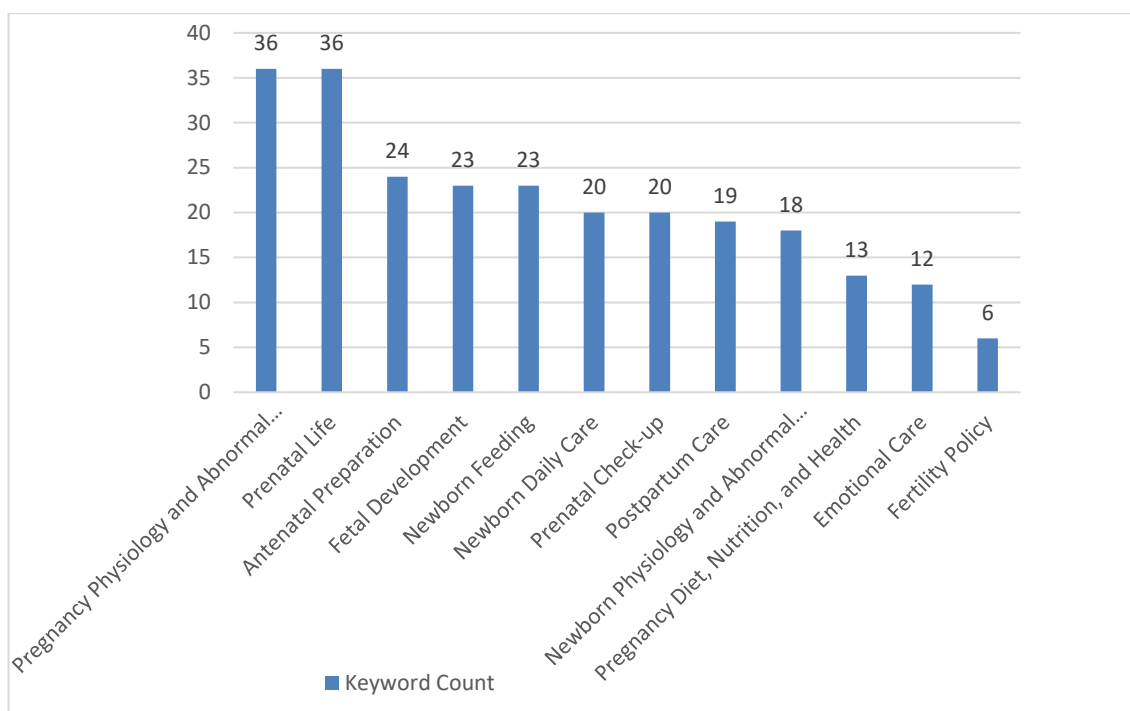


Figure 5. Keyword Clusters in the "Friend Circle" Module of the Forum

### 4.3 Comprehensive information needs

In the final integrated results, the topics are all from academic literature. The subdivision of subcategories and tertiary categories mostly originates from academic literature, while some tertiary categories supplemented based on forum keywords are marked with an asterisk. These representative forum keywords are used to demonstrate the vocabulary users would use to express information needs on online forums, and their corresponding clusters are shown in parentheses after the keywords. Some subcategories do not have representative keywords, indicated by "—", which suggests that users rarely express such needs on online forums. The integrated information needs categories and the representative keywords from online forums are listed in Table 8.

Table 8. Integrated Categories of Maternal and Infant Health Information Needs

Theme	Subcategory	Subcategory	Representative Keywords
Preconception Information Needs	Preconception Knowledge and Considerations	Preconception Methods and Pregnancy Status	—
		Eugenics Knowledge	—
		Preconception Medication	—

Theme	Subcategory	Subcategory	Representative Keywords
		Physical Adjustment and Lifestyle	—
Pregnancy Information Needs	Physiological Conditions and Symptoms During Pregnancy	Pregnancy Symptoms and Management	Morning sickness, Hardening, Dizziness, Headache, Backache, Tightness, Frequent urination (7)
		Abnormal Pregnancy and Complications	Preterm birth, Anaemia, Constipation (7)
	Diet and Nutrition	Pregnant Women's Dietary Advice and Taboos	Milk tea, Avoidance (2)
		*Specific Dietary Management	Early pregnancy, Blood sugar control, Sugar control, Reduction (6)
		Nutritional Supplements	Folic acid, Iron supplementation, Calcium tablets, Calcium carbonate, Iron protein (6)
	Healthcare and Disease Prevention	Physiological Healthcare	—
		Psychological Healthcare	Breakdown, Endurance, Days, Anxiety, Anger, Happiness, Tension (12)
		Pregnant Women's Medication Selection and Usage	Medication, Drugs, Pharmacy, Brand, Recommendation, Dosage (7)
		*Pregnant Women's Abnormal Symptoms and Management	Cramps, Lower abdomen, Dizziness, Nausea, Cold, Cough, Runny nose, Stuffy nose, Fever (7)
		Pregnancy Weight Management	—
		Pregnancy Self-Monitoring	—
	Prenatal Checkups	Creating a pregnancy file	Birth card, Display, Notification, File establishment, Appointment, Big card, Telephone (9)
		Prenatal Examination Related	Liver function, Blood draw, Laboratory tests, Blood routine, Urine routine, Glucose tolerance, Ultrasound, Maternal serum screening (5)
		Pregnancy Checkup Process and Considerations	Blood sugar, Fasting, Review (5)
		Pregnancy Checkup Indicator Analysis	Indicators, Test, View, Inform, Low (5)
		Pregnancy Checkup Timing	Delay, Pandemic (5, 10)
		Pregnancy Checkup Cost	Pregnancy, Examination, Cost (5)
		Pregnancy Checkup	Hometown, Prenatal examination

Theme	Subcategory	Subcategory	Representative Keywords
		Facility or Location Selection	(5)
	Fetal Development	Fetal Naming	Name, Newborn (13)
		Pregnancy Calculation	Estimated due date, Month (5, 13)
		Fetal Movement Monitoring	Fetal movement, Frequent (5, 13)
		Fetal Heart Monitoring	Belly button, Fetal heart, Monitoring (5, 13)
		Fetal Normal Developmental Features and Considerations	Development, Fetus (13)
		*Fetal Examination	Fetus, Screening, Heart, Separation, System, Umbilical cord (5, 13)
		Sex Prediction	Boy or girl, Boy, Girl, Expectation, Boy baby, Girl baby (5, 13)
		Prenatal Education	—
	Daily Life	Pregnant Women's Daily Care	Skincare, Weather, Air conditioning, Acne (12)
		Pregnant Women's Product Selection	Skincare products (12)
		Pregnancy Work	Suitable, Work, Working, Physical, Off work (12)
		Pregnancy Exercise	Exercise
		Pregnant Women's Daily Entertainment	Mobile phone (12)
		Sleep and Fetal Dreams	Dreaming, Dreaming about, Insomnia, Unable to sleep (12)
Delivery and Postpartum Information Needs	Prenatal Preparation	Symptoms and Responses to Labor	Initiation, Bathroom, Abdominal pain, Delivery, Regularity (11)
		Delivery Techniques and Considerations	—
		Induction of Labor	Inducing labor, Urgency, Methods (11)
		Selection of Delivery Method and Impact	Cesarean section, Vaginal delivery (11)
		Preparation of Delivery Items	Hospital bag (11)
		Choice of Delivery Hospital and Medical Staff	Delivery, Return to hometown (5)
		Delivery Costs	Price, Giving birth (11)
		Pain Relief During Delivery	Painless delivery, Effectiveness (11)

Theme	Subcategory	Subcategory	Representative Keywords	
Baby Health and Care Information Needs	Postpartum Recovery	Monthly Confinement	Monthly confinement centre (8)	
		Postpartum Diet and Nutrition	—	
		Postpartum Taboos and Considerations	Shampooing, Bathing, Confinement, Follow-up checkup, Rest (8)	
		Postpartum Recovery	Menstruation, Postpartum, Bleeding, Recovery, Repair, Pelvic floor (8)	
	Feeding and Care	Infant Daily Care	Sleeping, Burping, Height, Weight, Vision, Bathing (3)	
		Selection of Infant Medications	Hormones, Ointments (3)	
		Selection of Infant Products	Diapers, Clothes, Convenient, Disposable diapers (3)	
		Diet Related to Breastfeeding	Feeding, Frequency, Complementary food, Breastfeeding, Eating (4)	
		*Infant Examination and Vaccination	Hearing, Screening, Immunization, Vaccination, Influenza vaccine, Hip joint, Physical examination, Report (2)	
		Infant Physiological Conditions and Prevention	Abnormal Infant Behaviors and Responses	Head shaking, Refusal to eat, Spitting up milk, Dry heaving, Crying loudly, Refusal, Crying, Sweating (3)
			*Infant Development	Height, Weight, Teeth, Development, Milestones, Physical examination, Head shape (14)
	Infant Illnesses and Treatments		Ear, Eczema, Calcium deficiency, Blisters, Fingers, Pneumonia, Bloodshot, Forehead, Rash (7)	
	Care and Considerations During Infant Illness Periods		Supplementing calcium, Taking medication, Nursing, Improvement (4)	
	Infant Education	Parenting Knowledge and Experience Sharing	—	
Preschool Institution and Physician Selection		—		
Emotional Support	Interpersonal and Social Relationships	Sharing Experiences	Sharing, Experience, Unable to understand, Informing, Safety, Health, Success (15)	
		Seeking Social Support	Social circle, Friends (15)	
		Seeking Similar	Similar, Selection (15)	

Theme	Subcategory	Subcategory	Representative Keywords
Policy and System	Reproductive Policy and Information Consultation	Experiences	
		Marital and Family Relationships	Mother-in-law, Marriage, Care, Relationship (15)
		Social Insurance Policy and Procedures	—
		Reproductive Policy and Insurance	Allowance, Reproduction, Reimbursement (9)
		Reproductive Procedures and Document Handling	Prenatal certificate, Processing, Documentation (9)
	*Information Inquiry	Mother and Child, Manual, Unable to see, Data, Unable to find, Upload, Information (1)	
		*Medical Information	Work, Registration, Consultation, Addition, Outpatient, Arrangement (9)
	Maternal Leave and Labor Protection	Maternal Leave and Labor Protection	—

Note: \*Keyword Categories: 1. Information Query; 2. Newborn Examination; 3. Newborn Daily Care; 4. Newborn Feeding; 5. Pregnancy Examination; 6. Pregnancy Diet, Nutrition, and Health; 7. Pregnancy Physiology and Abnormal Symptoms; 8. Postpartum Care; 9. Reproductive Policies and Visits; 10. Epidemic Consultation; 11. Antenatal Preparation; 12. Pregnancy Life; 13. Fetal Development; 14. Newborn Physiology and Abnormal Symptoms; 15. Emotional Care. \*Subcategories in bold and marked with \* are newly supplemented content from forum keywords.

To measure demand intensity (NI), this study utilized a quantitative indicator that considers both the frequency of literature and the keyword count of demand categories (Lu et al., 2021), as shown in Equation (1):

$$Need\ Intensity\ (NI_i) = \alpha * \frac{F_i}{N_d} + (1 - \alpha) * \frac{N_i}{N_k} \quad (1)$$

Where  $F_i$  is the frequency of academic literature for the  $i_{th}$  category from Table 3.4,  $N_d$  is the total sum of academic literature samples.  $N_i$  is the number of keywords for the  $i_{th}$  category, and  $N_k$  is the total sum of keywords. The parameter  $\alpha$  determines the weight of document frequency and the number of forum keywords, and its value can be determined through graphical methods. In Figure 6,  $\alpha$  is assigned values of 0.4, 0.5, and 0.6, indicating that the value of  $\alpha$  affects the ranking of four different demand subcategories. Since the keywords from forums are more dispersed and less rigorous than the subcategories in academic literature, the weight of academic literature frequency should not be less than the weight of forum keyword counts; thus,  $\alpha = 0.4$

should be excluded. When  $\alpha$  equals 0.6, the NI differences among the three categories—infant physiological condition and prevention, fertility policies and information consultation, and postpartum care—are greater than the differences when  $\alpha$  equals 0.5. Therefore, this study chooses  $\alpha = 0.6$  to measure demand intensity. The frequency of academic literature, keyword counts, and demand intensity for each category are listed in Table 9.

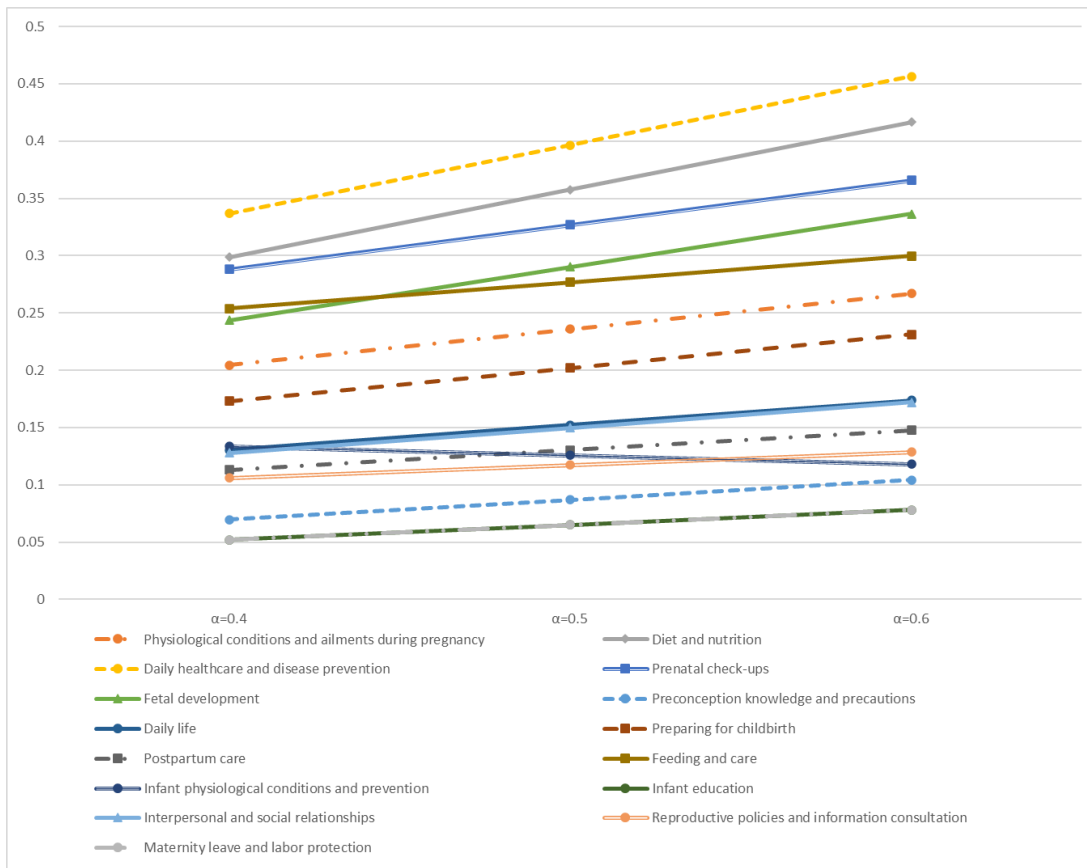


Figure 6. Demand Intensity at Different  $\alpha$  Values

Table 9. Demand Intensity for Maternal and Child Health Information

Topic	Subcategory	Frequency of Academic Literature	Keyword Count	Need Intensity (NI)
Preconception Information Needs	Preconception knowledge and precautions	4	0	0.10
Pregnancy Information Needs	Physiological conditions and ailments during pregnancy	9	37	0.27
	Diet and nutrition	15	29	0.42



Topic	Subcategory	Frequency of Academic Literature	Keyword Count	Need Intensity (NI)
	Daily healthcare and disease prevention	16	45	0.46
	Prenatal check-ups	12	61	0.37
	Fetal development	12	27	0.34
	Daily life	6	20	0.17
Preconception Information Needs	Preparing for childbirth	8	26	0.23
	Postpartum care	5	20	0.14
Preconception Information Needs	Feeding and care	9	75	0.30
	Infant physiological conditions and prevention	2	76	0.12
	Infant education	3	0	0.08
Emotional Support	Interpersonal and social relationships	6	18	0.17
Policy and System	Reproductive policies and information consultation	4	28	0.13
	Maternity leave and labor protection	3	0	0.08

#### 4.4 Maternal and infant health information needs categories

In this study, six main themes, fifteen subcategories, and sixty-eight tertiary categories of maternal and child health information demands were extracted from academic literature and online forums, further enhancing the understanding of maternal and child health information needs.

##### 4.4.1 The need for prenatal care and disease prevention

Among all information demand categories, the demand intensity for prenatal daily health care and disease prevention is the highest (NI=0.46), indicating the significant information needs of pregnant women in this area and highlighting their urgent concern for their own health during pregnancy. Information needs related to daily health care and disease prevention include prenatal disease prevention, medication safety, mental health care, weight management, and more. When pregnant women fall ill during

pregnancy, they experience anxiety about managing the illness and its impact on the fetus, and they seek advice and experiences from other pregnant women or healthcare professionals. For instance, one post asks, "*What should I do if I have a low fever, runny nose, and cough during pregnancy?*" Another post questions the impact of illness on the fetus: "*Does coughing in the late stages of pregnancy affect the baby in the womb?*"

Additionally, pregnant women have a high demand for information on medication during pregnancy, such as inquiries about whether it is safe to take medication for a cold during pregnancy. In another post, a pregnant woman seeks advice on medication choice for anaemia: "*What medication do pregnant moms take for anaemia?*" Due to hormonal changes, physical changes during pregnancy, uncertainty about childbirth and parenting, and role transitions, pregnant women often experience emotional stress. Many posts mention emotional stress, indicating the importance of providing emotional support and professional advice. For example, one post expresses anxiety: "*I'm a little anxious these days. The baby's biparietal diameter at thirty-six weeks is 9.6. I'm afraid it won't be good for a vaginal delivery. Should I consider a caesarean section in advance? The doctor at the maternal and child health centre said it's a bit big now, almost 6 pounds. How about you? When you gave birth, what was the biparietal diameter? Can you give me some advice?*"

Lastly, because weight management during pregnancy directly affects maternal and child health, pregnant women seek advice on weight management during pregnancy on the forum: "*Moms, how do you control your weight? I feel like I've gained several pounds, and it's not even March yet.*"

#### 4.4.2 Nutritional and dietary needs during pregnancy

The demand for information on diet and nutrition during pregnancy (NI=0.42) ranks second only to prenatal health and disease prevention. The most common issues under this theme include dietary advice during pregnancy and supplementation of nutritional substances. Pregnant women seek guidance on dietary choices and food selection during pregnancy. For example, one post asks, "*What do you eat during pregnancy to prevent hair loss? Do you eat bird's nest or something like that?*"

Additionally, pregnant women seek information on the timing of vitamin supplementation, as seen in a post asking, "*I'm 33 weeks pregnant. Do I still need to*

*take vitamin D drops?"* and seek advice on brand choices for nutritional supplements, as inquiring, *"What brand of folic acid do you all take?"* It is worth noting that this study identified specific dietary management in addition to the information demand categories extracted from academic literature, based on textual analysis of online forum posts. Pregnant women with special conditions such as diabetes and hypertension during pregnancy have specific information needs in dietary management. For instance, a pregnant woman inquires, *"My blood sugar is a bit high. Besides eating small meals, what other dietary issues should I pay attention to?"*

#### 4.4.3 Prenatal examination needs

Pregnant women have a high demand for information related to prenatal examinations (NI=0.37), primarily focusing on establishing medical records, knowledge about prenatal check-ups, and the institutions and costs involved. When initially establishing medical records, pregnant women often have doubts about the timing and requirements, as seen in a post asking, *"Does anyone know if you need to wait until 12 weeks to establish medical records at Lingxi Health Centre? What documents do I need to bring?"*

Regarding knowledge about prenatal check-ups, most posts are related to check-up timing, analysis of check-up results, check-up procedures, and precautions. For instance, pregnant women seek confirmation of their check-up results from online doctors: *"Doctor, some of my test results are out, and I see a few indicators showing abnormalities. Can you see if it's a big problem?"* Another post inquires about precautions for prenatal check-ups: *"Has anyone been to Shao Yifu Hospital for prenatal check-ups recently? What should I pay attention to?"* Pregnant women also seek evaluations of prenatal examination institutions and information on examination costs from others' experiences and analyses, such as inquiring about the appointment process for a 4D ultrasound: *"Moms, do you need to make an appointment directly at Dongyang Maternity and Child Health Hospital for a 4D ultrasound, or can you make an appointment online? How much does it cost?"*

Additionally, some pregnant women inquire about issues related to free examinations, for example, asking how to use free prenatal screening received at the time of establishing medical records: *"How do I interpret the free first-trimester screening results received at the medical records office?"*

#### 4.4.4 Fetal development needs

Pregnant women have a relatively high demand for information about fetal development during pregnancy (NI=0.34), primarily divided into monitoring fetal development, factors influencing normal fetal development, fetal examinations, and naming and gender speculation. Through prenatal examinations, pregnant women can monitor the development of the fetus, assess whether fetal development is normal, and pay attention to fetal movements and heart rates through self-monitoring. Pregnant women hope to obtain methods for determining fetal movements and advice on whether fetal movements are normal. For example, one post mentions, *"I'm 16 weeks pregnant, and I feel something moving when I put my hand on my belly. It feels like a heartbeat. Is it fetal movement?"* Another post asks, *"I'm 20 weeks pregnant. Sometimes there are obvious fetal movements, sometimes there are none. Is this normal?"*

When abnormalities are found during fetal examinations, pregnant women typically experience anxiety and seek explanations and treatment methods for abnormal conditions from online doctors or seek communication and experience sharing with other pregnant women with similar conditions on forums, to gain emotional and treatment decision support. For example, *"I'm 30 weeks pregnant, and I went for a prenatal check-up today. The doctor said the amniotic fluid is low, the fetal position is incorrect (transverse), the head circumference is slightly small, and the lungs are separated. With so many problems, what should I do?"*

Additionally, pregnant women may worry about the effects of their own abnormal symptoms on fetal development: *"Will sinus bradycardia affect fetal development?"* Furthermore, some questions involve calculations related to pregnancy, such as, *"I've had the nuchal translucency test. Today is 12+6 weeks. Can I calculate the due date now?"* Lastly, pregnant women hope to determine the fetal gender by sharing nuchal translucency test results: *"The nuchal translucency test report is out. Experienced moms, can you help determine if it's a boy or a girl?"*

#### 4.4.5 Infant feeding and care needs

In the dimension of infant health and nurturing, expectant mothers have the highest information demand for infant feeding and care (NI=0.30). To prepare for the birth of the baby, pregnant women need to prepare dietary and daily necessities related to

newborns before delivery. Through recommendations and sharing on online forums, pregnant women can obtain recommendations for infant products. For example, some pregnant women seek recommendations for diapers from other users: "*Any recommendations for baby diapers?*"

Additionally, since many mothers are giving birth for the first time, they lack knowledge about the daily care and feeding of newborns. Therefore, mothers seek information on infant hygiene, breastfeeding, mixed feeding, and medication choices from other mothers on online forums. For example, a pregnant woman seeks advice on feeding methods: "*Are there any mothers who feed their babies exclusively with formula milk?*" Furthermore, after the baby is born, various examinations and vaccinations are required. Mothers obtain information on examination or vaccination schedules, costs, and necessity through online forums. For example, "*Do you all give your children self-paid vaccinations?*" They also seek interpretations of examination reports from professional doctors. For instance, "*I want to consult about my baby's 6-month check-up. The result of the D2 test is 1.49. Is this normal, or does it need to be supplemented?*"

#### 4.4.6 Prenatal preparation needs

Pregnant women's information needs before childbirth include knowledge related to childbirth, preparation of delivery-related items, selection of hospitals and medical staff, and costs (NI=0.23). Before delivery, pregnant women inquire about signs of labor and coping methods, choices of delivery methods and their effects, and lists of items needed for delivery preparation. Some women with overdue pregnancies experience anxiety and seek reasons and solutions for not going into labor after the expected due date on forums. For example, a post asks: "*Should I still go for prenatal check-ups now that the due date has arrived? Or should I wait for labor to start?*"

Additionally, with the maturity and popularity of epidural anesthesia technology, more and more pregnant women are paying attention to painless delivery. They seek information on the implementation process and effects of painless delivery through forum discussions to help them decide whether to choose painless delivery during childbirth. For example, a pregnant woman asks about others' choices for painless delivery and inquires about the cost and medical insurance policies: "*Hey ladies, are you planning to have painless childbirth? How much does it cost for a shot of painless anesthesia in Yueqing? Is it covered by medical insurance, or is it self-paid?*"

Lastly, pregnant women inquire about information on hospitals or medical staff and delivery costs through online forums before childbirth, hoping to obtain evaluations of a particular hospital or doctor and the cost of delivery to help them make decisions about hospital and medical staff selection. For example, *"Hey moms who have given birth this year, can you please share your thoughts on whether it's better to choose Doctor A or Doctor B at the Second Hospital of Wenzhou? Which one is more expensive, and how is the service?"*

#### 4.4.7 Postpartum recovery and care needs

Compared to the information needs during pregnancy, women's demand for information on postpartum recovery and care is relatively low (NI=0.15). However, they still show some interest, particularly in selecting postpartum care facilities. Some pregnant women inquire about how to choose postpartum centers and maternity nurses. This indicates that pregnant women start preparing for their postpartum life and health in advance, seeking information and selecting appropriate postpartum care services.

Regarding postpartum care services, women hope to obtain evaluations and recommendations for postpartum centers or maternity nurses through online communities. For example, there's a post asking: *"My due date is in September. Can anyone recommend a maternity nurse?"* Additionally, women inquire about taboos and precautions during postpartum life, as well as normal postpartum recovery situations and methods, such as cleaning and care, pelvic floor repair, and postpartum lochia conditions. For instance, a pregnant woman asks about the normal situation regarding postpartum lochia: *"Is it normal not to have lochia four or five days after giving birth?"* Lastly, women also show some concern about postpartum diet and nutrition.

#### 4.4.8 Reproductive policies needs

Pregnant women's attention to reproductive policies is relatively low (NI=0.13), focusing mainly on the collection of maternity insurance and allowances, reimbursement procedures for childbirth expenses, and the processing procedures for reproductive documents and certificates. For example, a post inquires about the process of obtaining a birth permit for a second child: *"Do we need to apply for a birth permit for the second child now?"* Furthermore, since the "Mother and Child Health Handbook" app synchronizes data such as prenatal examination results and newborn

information, users may seek solutions to problems such as unsynchronized information or inability to access certain information in doctor Q&A sessions. For instance, someone asks: *"Hello, doctor. I still can't see my child's six-month check-up information in the mother and child handbook. Has it not been uploaded yet?"*

Additionally, due to the convenience of contacting their attending doctors through online platforms, pregnant women directly ask doctors in the Q&A module for information on whether the doctor is available for consultation and how to make appointments. For example: *"Do I need to make an appointment in advance for my newborn's vaccination and check-up, or can I just go on the day?"*

#### 4.4.9 Preconception knowledge and considerations

Among all dimensions, pregnant women have the lowest demand for information during the preconception period (NI=0.10). This category did not appear in the analysis results of online forums, possibly because the "Mother and Child Health Handbook" app mainly targets users who register after becoming pregnant. Therefore, women rarely focus on this app during the preconception period. Analysis of preconception information needs in academic literature reveals four main aspects: preconception methods and pregnancy confirmation, eugenics knowledge, preconception medications, and lifestyle adjustments. Among four academic papers related to preconception, three mentioned that women are particularly interested in information about preconception methods and confirming pregnancy. Couples planning to conceive have a high demand for information regarding the best fertility timing, methods for calculating ovulation cycles, and how to increase the chances of conception (Zhang et al., 2021).

Additionally, women often seek confirmation of pregnancy by disclosing recent sexual activity and symptoms suggestive of pregnancy (Zhang et al., 2021). Studies also show that women seek eugenics knowledge and preconception experiences during this period. Moreover, the rational use of medications during preconception, including prenatal vitamins, fertility-assisting drugs, and medications for specific health issues, is crucial for improving pregnancy success rates and healthy embryo development (Zhang et al., 2021). Lastly, lifestyle adjustments, such as moderate exercise, healthy dietary habits, and avoiding harmful habits, are key aspects of preconception information needs (Chen & Zheng, 2023).

#### 4.4.10 Infant education and labour protection

Among all subcategories of information needs, the demand for infant education and maternity leave/labor protection is the lowest, with an NI of 0.08 each. Analysis shows that these two subcategories only appear in academic literature, possibly due to their low TF-IDF values hindering their discovery in online forums. According to academic literature analysis, some pregnant women are concerned about infant education and seek recommendations for childcare institutions and healthcare providers (Chen & Zheng, 2023). Additionally, some working women hope to communicate with others through the internet about maternity leave during and after pregnancy, seeking protection for their relevant labor rights (Cheng & Deng, 2022).

### 4.5 Information services of APPs

The videos and articles on the "Maternal and Child Health Handbook" app were counted according to their respective subcategories, as shown in Figure 7, depicting the distribution of information service topics on the app. The statistical results reveal that the maternal and child health information service topics on the app are extensive but unevenly distributed.

The primary health information service topics on the app are related to pregnant women, including Physiological Conditions and Symptoms During Pregnancy (22.19%), Prenatal Check-ups (16.23%), Daily Life During Pregnancy (13.25%), Daily Health Care and Disease Prevention During Pregnancy (7.62%), and Diet and Nutrition During Pregnancy (7.62%). Furthermore, the app provides information service topics related to fetuses and newborns, which are of greater concern to expectant and postpartum women, such as Infant Physiological Conditions and Treatments (8.61%), Fetal Development (7.62%), and Feeding and Care (2.98%). Additionally, other maternal and child health information services cover topics related to preconception, prenatal, postnatal, and infant education, including Prenatal Preparation (4.97%), Postpartum Care (3.31%), Labor Knowledge (2.65%), Preconception Knowledge and Precautions (2.32%), and Infant Education (0.33%).

The final information service coding scheme and the number of articles or videos in each category as a percentage of the total are summarized in Table 10, comprising 5 primary categories, 14 subcategories, and 48 tertiary categories.



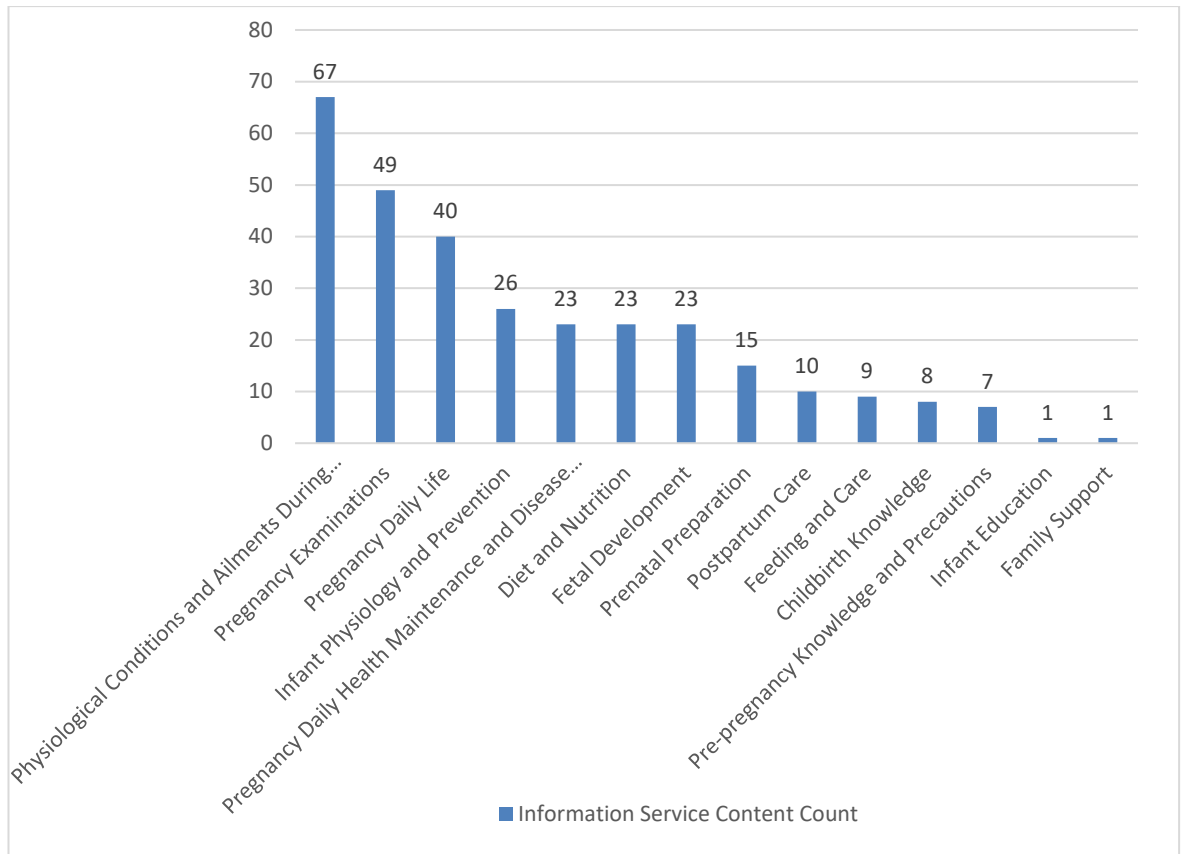


Figure 7. Distribution of Maternal and Child Health Information Service Topics

Table 10. Classification Results of Information Service Topics on the "Maternal and Child Health Handbook" App

Category	Subcategory	Third-level Category	Number of Videos or Articles	Total Percentage
Pre-pregnancy Guide	Pre-pregnancy Knowledge and Precautions	Gynecological Diseases and Fertility	4	2.32%
		Pre-pregnancy Methods and Pregnancy Confirmation	3	
		Total	7	
Pregnancy Encyclopedia	Physiological Conditions and Ailments During Pregnancy	Common Symptoms and Their Management	45	22.19%
		Pregnancy Complications	13	
		Pregnancy Complicated by Medical and Surgical Conditions	6	
		Physiological Changes and Symptoms During Pregnancy	3	
		Total	67	

Category	Subcategory	Third-level Category	Number of Videos or Articles	Total Percentage
	Pregnancy Daily Health Maintenance and Disease Prevention	Pregnancy Health Monitoring	9	7.62%
		Gestational Weight Management	8	
		Medication Selection and Usage During Pregnancy	5	
		Management of Special Circumstances	1	
		Total	23	
	Pregnancy Examinations	Antenatal Examination Related	27	16.23%
		Analysis of Antenatal Examination Indicators	21	
		Documentation and Registration	1	
		Total	49	
	Diet and Nutrition	Dietary Recommendations and Taboos for Pregnant Women	17	7.62%
		Specific Dietary Management	4	
		Nutritional Intake and Supplementation for Pregnant Women	2	
		Total	23	
	Fetal Development	Fetal Monitoring	6	7.62%
		Fetal Movement Monitoring	5	
		Fetal Abnormalities and Abnormal Fetal Appendages	5	
		Fetal Education	3	
		Fetal Heart Monitoring	2	
		Weight Prediction and Management	2	
		Total	23	
	Pregnancy Daily Life	Lifestyle and Daily Management Habits	12	13.25%
		Environmental and Activity Safety Guidance	11	
		Routine Care for Pregnant Women	5	
		Psychological and	5	

Category	Subcategory	Third-level Category	Number of Videos or Articles	Total Percentage
Childbirth and Postpartum Recovery		Family Relationship During Pregnancy		
		Exercise During Pregnancy	4	
		Sleep	2	
		Employment During Pregnancy	1	
		Total	40	
	Childbirth Knowledge	Symptoms of Labor and Coping Strategies	8	2.65%
		Total	8	
	Prenatal Preparation	Choice of Delivery Method	7	4.97%
		Considerations for Delivery	3	
		Labor Pain Relief	3	
		Complications During Labor	1	
		Preparation of Items for Labor	1	
	Postpartum Care	Total	15	
		Postpartum Care and Recovery	6	3.31%
		Postpartum Confinement Customs	2	
Postpartum Diet and Nutrition		1		
Postpartum Taboos		1		
Feeding and Care	Total	10		
	Infant Daily Care	4	2.98%	
	Infant Diet and Digestion	4		
	Breastfeeding	1		
	Total	9		
Childcare	Infant Physiology and Prevention	Infant Illnesses and Treatments	22	8.61%
		Infant Development and Growth	2	
	Infant Education	Care and Considerations During Infant Illnesses	2	
		Total	26	
		Development of Habits	1	0.33%
	Total	1		

Category	Subcategory	Third-level Category	Number of Videos or Articles	Total Percentage
Other	Other	Family Support	1	0.33%

Through content analysis of maternal and child health-related (MCH) APPs information services, the frequency of the number of corresponding APPs for each tertiary category was calculated, as shown in Table 11. Table 11 displays the results of content analysis for four maternal and child health-related APPs, including categories, subcategories, tertiary categories, and the frequency of APPs corresponding to each tertiary category.

Table 11. Main Categories of Information Services in Maternal and Child Health-Related APPs

Category	Subcategory	Tertiary Category	App Frequency	
Pre-pregnancy	Pre-pregnancy knowledge	Pre-pregnancy methods and pregnancy confirmation	4	
		Fertility recipes	3	
		Gynecological diseases and fertility	3	
	Physical examination	Pre-pregnancy checklists	3	
		Weight records	2	
Pregnancy	Physiological conditions and symptoms	Pregnancy physiological changes and symptoms	2	
		Common symptoms during pregnancy and their management	3	
		Pregnancy complications	3	
		Pregnancy complications with internal and surgical diseases	2	
	Daily care and disease prevention		Maternal drug selection and medication precautions	3
			Pregnancy weight management	3
			Pregnancy health monitoring	3
			Handling special situations	2
			Establishing medical records	2
	Check-up related		Check-up schedules	4
			Pregnancy check-up indicators analysis	4
			Fetal movement monitoring	4
			Fetal heart monitoring	3
Fetal heart monitoring			4	
Diet and nutrition		Fetal abnormalities and fetal appendage abnormalities	3	
		Pregnancy recipes	4	

Category	Subcategory	Tertiary Category	App Frequency
		Specific diet management	3
		Maternal nutrition intake and supplementation	4
	Fetal development	Weight prediction and management	2
		Prenatal education	3
	Pregnancy lifestyle	Maternal daily care	4
		Lifestyle habits and daily management	3
		Environmental and activity safety guidance	3
		Pregnancy work	2
		Pregnancy exercise	3
		Emotional care	2
		Sleep	2
	Childbirth knowledge	Childbirth knowledge	4
	Pre-delivery preparation	Delivery precautions	4
		Abnormal delivery	3
		Delivery method selection	3
		Pre-delivery item preparation	3
		Labor pain relief	2
Childcare	Postpartum recuperation	Postpartum customs	3
		Postpartum diet and nutrition	3
		Postpartum taboos	3
		Postpartum care and recovery	4
	Baby feeding	Infant daily care	4
		Breastfeeding	4
		Infant diet and digestion	4
	Physiological conditions and prevention	Infant development and growth	4
		Common infant illnesses	4
		Infant illness care and precautions	3
	Baby growth	Early childhood education and intelligence	4
		Habit formation	2
		Baby naming	1
Other	Other	Family support	2
		Finding a childcare nanny	1

Based on the coding of information services in the "Maternal and Child Health Handbook" app and subsequent analysis of maternal and child health-related (MCH) APPs, the final hierarchical categories of information services comprised 4 main

categories, 15 subcategories, and 53 tertiary categories. The thematic classification results of information services in MCH APPs indicate a rich variety of content covering various stages such as pre-pregnancy, pregnancy, postpartum, and childcare. This content encompasses aspects including maternal and child healthcare, disease prevention and treatment, nutritional guidance, and psychological counselling. In terms of the distribution of categories, pregnancy and childcare emerge as focal points of MCH app attention. Pregnancy-related information services primarily include prenatal care, prenatal examinations, prenatal nutrition, and fetal development, while childcare services mainly focus on infant feeding, care, education, and health. Moreover, MCH APPs offer diverse forms of information services, not only through traditional text and image formats but also extensively employing video and audio formats, which are vivid, illustrative, and easy to comprehend and accept. However, it is evident that there are differences in the quality of information services among different MCH APPs. Some APPs provide comprehensive, accurate, and reliable information services, while others may have deficiencies in their content.

## 5 Discussion

### 5.1 The gap between information needs and services

This study employs a qualitative content analysis approach to comprehensively compare information needs with information services, aiming to determine whether there are disparities between them and identify the specific areas of discrepancy. Each level of information needs is matched with corresponding levels of information services. This matching process is conducted by two coders, and the inter-coder reliability is calculated using Holsti's formula (Holsti, 1969) as 0.875. To gauge the degree of alignment between information needs and information services, this study utilizes a quantitative metric - the matching degree (MD) (Lu et al., 2021) , as shown in Equation (2):

$$\text{Matching Degree } (MD_i) = \frac{MNS_i}{TNS_i} * 100\% \quad (2)$$

Where  $MNS_i$  denotes the number of matched subcategories within category  $i$ , and  $TNS_i$  represents the total number of subcategories of category  $i$  listed in Table 7. The matching degree indicates the percentage of subcategories within each demand category that have been met by existing information services.

Through content analysis comparing the categories in Table 7 and Table 10, it is evident that there exists a gap between maternal and child health information needs and services. Each subcategory of information needs in Table 7 is matched with categories or subcategories of services in Table 4.2 that can fulfil these needs. For instance, in the information needs category "Feeding and Care," the subcategory "Infant Breastfeeding Diet Related" can be matched with service subcategories such as "Breastfeeding" and "Infant Diet and Digestion." However, three demand subcategories, namely "Infant Medication Selection," "Infant Product Selection," and "Infant Check-ups and Vaccination," cannot be matched with any service categories or subcategories. An information need can be fulfilled by multiple service categories or subcategories, and vice versa, indicating a many-to-many correspondence between demand and service categories. In some cases, certain categories and subcategories of information needs cannot be matched with service categories or subcategories, suggesting a gap between the two.

The gap between maternal and child health information needs and services is illustrated in Table 12. The qualitative descriptions of demand intensity and matching degree are based on the threshold division of relevant coefficient values (Taylor, 1990). The thresholds for demand intensity and matching degree are categorized into three levels: weak/few matches for the range of 0.0-0.35, moderate/partial matches for 0.36-0.67, and strong/most matches for 0.68-1.0 (Taylor, 1990). Each unmatched subcategory in each demand category is listed in the last column of the table, indicating the gap between user information needs and the information services provided by the app, thus providing guidance for information providers to enhance their services.

Table 12. Discrepancies Between Maternal and Child Health Information Needs and Services

<b>Information Needs Subcategory</b>	<b>Demand Intensity</b>	<b>Matching Degree</b>	<b>Unmatched Subcategories</b>
Daily Health Care & Disease Prevention	0.49, Medium	1, Most	—
Diet & Nutrition	0.45, Medium	1, Most	—
Prenatal Checkups	0.40, Medium	0.57, Partial	Prenatal checkup procedures and precautions, Prenatal checkup costs, Prenatal checkup institution or location selection
Fetal Development	0.36, Medium	0.78, Most	Pregnancy calculation, Gender prediction
Feeding & Care	0.33, Weak	0.4, Partial	Infant medication selection, Baby product selection
Maternal Physiological Conditions & Symptoms	0.29, Weak	1, Most	—
Antenatal Preparation	0.25, Weak	0.63, Partial	Labor induction, Maternity hospital and healthcare provider selection, Delivery costs
Daily Life	0.19, Weak	0.83, Most	Maternal daily entertainment
Interpersonal & Social Relationships	0.19, Weak	0.5, Partial	Sharing experiences, Seeking similar experiences
Postpartum Recovery	0.16, Weak	0.75, Most	Institution selection
Physiological Conditions & Prevention	0.14, Weak	1, Most	—
Reproductive Policy & Information	0.14, Weak	0, Rarely	Social security policies and procedures, Reproductive policies and insurance, Reproductive procedures and document processing, Information retrieval, Medical visit information
Preconception	0.11, Weak	0.5, Partial	Eugenics knowledge, Body



Knowledge & Precautions			adjustment and life
Infant Education	0.08, Weak	0.5, Partial	Infant care institution and physician selection
Maternity Leave & Labor Protection	0.08, Weak	0, Rarely	Maternity leave and labor protection

The matching analysis reveals that while most of the information needs in categories such as Daily Health Care and Disease Prevention, Diet and Nutrition, Physiological Conditions and Symptoms During Pregnancy, Daily Life, Postpartum Care, and Physiological Conditions and Treatments have been adequately addressed, there still exists a noticeable gap between maternal and child health information needs and services. The information services provided by the Maternal and Child Health Handbook app fail to fulfil some critical user information needs. According to the results in Table 11, expectant and postpartum mothers have high information needs regarding prenatal check-ups, fetal development, infant feeding and care, and prenatal preparation, yet these needs are not fully met to some extent. Unmatched information needs in prenatal check-ups include the process and precautions of prenatal examinations, timing, costs, and the selection of prenatal examination institutions or locations. Information needs related to fetal development involve choosing a name for the fetus and calculating the gestational period. Unmatched information needs in infant feeding and care encompass the selection of infant medications and products, while unmatched categories in prenatal preparation include induction of labor, hospital and medical staff selection, and childbirth costs. These diverse information needs reflect the strong desire of expectant and postpartum mothers to fully understand and cope with pregnancy and postpartum stages. However, current information services fail to adequately meet their needs in these critical areas, highlighting the urgent need to improve existing services to address maternal and child health needs comprehensively and accurately.

Furthermore, although information needs regarding preconception knowledge and precautions and infant education are relatively low, the unmatched information needs in these two aspects should not be overlooked. Unmatched information needs categories in preconception knowledge and precautions include eugenics knowledge and lifestyle adjustments, while unmatched categories in infant education include the selection of childcare institutions and physicians. This indicates a potential gap in information

services that need to be addressed more specifically to meet the needs of women during preconception and new mothers in these areas. Information on eugenics knowledge and lifestyle adjustments may affect prenatal health and fetal development, while the selection of childcare institutions and physicians is closely related to infants receiving quality education. Therefore, to enhance the quality of information services, it is essential to ensure that information in these important areas is fully covered to meet the comprehensive information needs of expectant and postpartum mothers.

Finally, information needs related to reproductive policies and work-related issues and maternity leave are completely unmatched. Although the information needs of expectant and postpartum mothers in this regard are relatively low, it reveals that existing reproductive policies and information related to maternity leave are not fully matched. The low information needs of expectant and postpartum mothers in this regard may be due to the failure to communicate information in a timely and clear manner. Understanding the reasons for this difference is crucial for improving reproductive policies and information services related to maternity leave to ensure that expectant and postpartum mothers can access comprehensive information to meet their needs.

In summary, these unmatched information needs can be categorized into two types: one type is the information needs that online mobile applications providing information services cannot fulfill or cannot unilaterally fulfill. For example, gender prediction of fetuses is not allowed to be provided in domestic hospitals, so online mobile applications cannot provide corresponding information services. As for information needs such as prenatal examination and childbirth cost, selection of childbirth hospitals and medical staff, childcare institutions and physicians, the charging standards of different hospitals or institutions vary in different regions as well as the services and medical staff provide. Thus, it requires information service providers to cooperate with hospitals or institutions to provide comprehensive information to users as much as possible. The other type is the information needs that information service providers have not considered, such as preconception eugenics knowledge, lifestyle adjustments, prenatal examination processes and precautions, gestational period calculation, reproductive-related policies, and maternity leave and labor protection. By refining the information services provided by online mobile applications, these needs can gradually be met.

Furthermore, matching degree, as a quantitative index defined to measure the gap between information needs and services, is only a symbol of the coverage of matching information needs. Although some information needs are fully matched, it does not mean that online mobile applications do not need to improve information services. For example, in the "Physiological Conditions and Treatments" category, the information needs related to "Infant Development" include aspects such as the infant's height, weight, teeth development, and head shape, while the provided information services only address the needs related to height. Similarly, the fact that some information needs are unmatched does not mean that they are not met at all; these needs can be met through other means on the platform. For example, in the category of "Interpersonal and Social Relationships," information needs related to "Sharing Experiences" and "Seeking Similar Experiences" require interactive features, which cannot be fulfilled by information services such as videos and articles provided by online mobile applications but can be met through online forums and friendship modules on the platform, providing users with corresponding channels to meet their information needs.

## 5.2 Suggestions for APPs development

In response to the information needs overlooked by information service providers, this study proposes the following suggestions from the perspectives of information service categories and the organization and implementation of software systems, aiming to provide reference for the high-quality development of mother and baby health information services in online mobile applications. The suggestions are summarized in Table 13.

Table 13. Suggestions for APPs development

Perspectives	Suggestions
Information Service Categories	Health monitoring and knowledge dissemination during pregnancy Comprehensive information on infant feeding and care Specialized preconception advice module Policy and institutional guidelines
The Organization and Implementation of Software Systems	Function optimization Designing a comprehensive taxonomy Structured information needs

### 5.2.1 Health monitoring and knowledge dissemination during pregnancy

According to the results of the intensity of maternal and child health information needs, pregnant women have relatively high demand intensities for prenatal examinations and fetal development among all categories of needs, which are 0.4 and 0.36 respectively. They seek to understand the procedures and timing of prenatal examinations, relevant precautions, and methods for estimating gestational age. However, the existing services providing prenatal examination and fetal development information have matching degrees with the needs at 0.57 and 0.78 respectively, corresponding to partial matching and mostly matching, both of which fail to adequately meet users' information needs in these aspects. Therefore, information service providers need to improve their services accordingly to better meet users' needs in this high demand but inadequately matched aspects.

Research has shown that visual guides and interactive tools can present prenatal examination procedures and precautions in a more intuitive and understandable manner, enhancing users' understanding and engagement in prenatal care, and reducing anxiety that may arise from information overload or inappropriate expression (Menon et al., 2021). Therefore, for prenatal examinations, it is recommended to include visual guides and interactive tools to detail the examination procedures and precautions in a combination of graphics and text, while helping users simulate expected experiences through interactive tools to alleviate anxiety.

Additionally, Leonard et al. (2021) demonstrated the potential role of technology in promoting behavioural changes during pregnancy. Therefore, in terms of fetal development information needs, it is suggested to design interactive pregnancy calculators to provide milestone tracking, allowing users to gain deeper insights into the fetal development process. Furthermore, Pollak et al. (2014) showed the effectiveness of providing personalized information via text messages to prevent excessive weight gain in pregnant women. Therefore, offering regular knowledge updates helps maintain pregnant women's ongoing attention to pregnancy, enabling them to acquire comprehensive and useful information, including changes during pregnancy, nutritional requirements, exercise recommendations, etc., to promote positive health decisions.

### 5.2.2 Comprehensive information on infant feeding and care

The newborn period is a critical stage in the lifecycle, crucial for the health and well-being of infants and their families. According to research results, the matching degree between the information demand and services for infant feeding and care is 0.4, only partially matched. The unmatched demand is reflected in new mothers' difficulty in obtaining comprehensive information on infant medication and product selection. Existing mother and baby health information services have failed to meet users' information needs well in these aspects. Therefore, to provide comprehensive support for existing information needs, it is recommended to develop professional medication and product selection guides to ensure that parents can make informed decisions.

Firstly, for infant medication, the guide should cover a broad spectrum of scenarios, including but not limited to disease prevention, treatment, and basic healthcare. It should provide information on the purposes, dosages, frequencies, and timing of various medications to meet the needs of infants with different health conditions. Emphasis can be placed on usage instructions for infant medications to ensure parents understand and correctly adhere to dosage instructions. Besides, for the selection of infant supplies, the guide should encompass various products required for daily care, such as diapers, bathing products, bedding, etc.

Additionally, the guide should cover feeding utensils for both breastfeeding and formula feeding scenarios to provide comprehensive information. For each product, it can include brand comparisons, ingredient analyses, usage methods, storage requirements, etc., to assist parents in making choices that align with the needs of their infants and family situations. The guide for infant supplies should particularly emphasize safety assessments to ensure purchased items meet safety standards and minimize potential risks. Furthermore, to enhance the practicality of the guide, information can be presented through a combination of graphics, demonstration videos, or interactive elements to make it more vivid and understandable.

Lastly, it is recommended to regularly update the guide's content to reflect the latest medical research and market changes, ensuring that the information users receive is accurate and comprehensive. By utilizing professional guides, information services regarding infant feeding and care will better meet the needs of parents, enhancing their attention to and level of care for infant health.

### 5.2.3 Specialized preconception advice module

During the preconception stage, obtaining professional medical advice is crucial to ensuring a healthy conception process (Dean et al., 2014). According to the analysis of differences between information needs and services, the matching degree for preconception knowledge and precautionary information needs is only 0.5, with unmet information needs evident in the lack of knowledge regarding eugenics-related information and recommendations for reasonable physical adjustments. Therefore, it is recommended to introduce preconception advice provided by professional doctors or experts, covering various aspects such as lifestyle, genetic factors, eugenics knowledge, etc. Bala et al. (2021)'s research reviewed the impact of lifestyle factors on fertility, emphasizing the importance of paying attention to these factors during the preconception period .

By citing expert opinions and relevant studies, knowledge about lifestyle factors to consider during preconception, such as quitting smoking, alcohol cessation, and maintaining regular sleep patterns, can be provided to support the scientific basis of these recommendations. Ioannides (2017)'s study highlighted the importance of genetic factors in reproductive disorders, supporting the recommendation to provide relevant knowledge and consultation services. By offering knowledge about genetic diseases and genetic counselling provided by professional doctors, eugenics knowledge services enable users to understand the role of family medical history and genetic factors in preconception decision-making, helping couples better understand potential genetic risks.

Additionally, personalized preconception plans can be provided, customized based on users' physical conditions, lifestyle habits, and work environments (Bala et al., 2021). For example, advice can be tailored according to the specificities of different users' professions. Integrating a preconception module into APPs will help improve users' knowledge levels during the preconception process and better prepare them for a healthy pregnancy journey.

### 5.2.4 Policy and institutional guidelines

Women during the gestation period seek information related to childbirth policies and institutions. For pregnant women, understanding childbirth policies enables them to be

aware of their rights, including maternity leave and related medical benefits. This transparency in information helps alleviate psychological stress during pregnancy, allowing them to focus more on a healthy gestation process. However, research on disparities between information needs and services reveals that the matching degree for childbirth policies and maternity leave with labor protection is both 0, indicating that information services in these areas fail to meet identified user needs.

Although users may not have high information needs in this regard, providing information services in this area ensures that users can access accurate and comprehensive information support when needed. Therefore, to provide more comprehensive information services, it is recommended to develop detailed interpretations of social security policies, including thorough guidance on reimbursement scope, application conditions, and processing procedures. Hyde et al. (1995) studied the impact of maternity leave on women's mental health, emphasizing the importance of statutory maternity leave. Regarding maternity leave and labor protection, information on maternity leave and labor protection regulations can be provided, including related rights and benefits. Clearly defining statutory maternity leave periods, salary guarantees, etc., helps users understand their rights. Studies have shown that experience sharing has a significant impact on decision-making (Bullington et al., 2022).

To enrich the user experience, real application processes, insurance purchases, and maternity leave experiences can be collected through user cases and experience sharing, encouraging users to share and communicate. Through these measures, the aim is to increase users' awareness of childbirth policies and ensure that their statutory rights are fully protected.

#### 5.2.5 Function optimization

Regarding function optimization, users of mobile applications for maternal and child health have a high demand for recommendation and evaluation information. According to the analysis of the disparity between demand and service in maternal and child health information, unmet information needs in subcategories such as prenatal examinations, prenatal preparation, postpartum care, and infant education are concentrated in the selection of prenatal examination institutions, hospitals and medical staff, postpartum care centers, and childcare institutions. It is evident that users want recommendation and

evaluation information in these areas. However, the questions posed in response to this demand are repetitive, and answers vary.

Moreover, there is a large number of posts on forums, making it difficult for users to draw conclusions during information search. Therefore, maternal and child health-related mobile applications should address this pain point in user demand and improve and optimize their functionality. A separate recommendation and evaluation module can be implemented based on in-depth research into user needs. For example, users with prenatal examination experience can evaluate prenatal examination institutions based on dimensions such as appointment difficulty, cost, waiting time, and environmental services, and supplement relevant information about these institutions. Other users can use this module to retrieve detailed information about prenatal examination institutions when needed to make comprehensive decisions.

Additionally, setting up the recommendation and evaluation module can help online community forums in maternal and child health-related APPs to accumulate valuable information, better manage knowledge, help users access the required information more conveniently, avoid identifying a large amount of redundant information, and improve the efficiency of effective information retrieval.

Optimization should address issues such as redundant classification in existing functional modules. For example, in the "Maternal and Child Health Handbook" APP, the category names "childcare" and "baby" under the "Doctor's Voice in Three Minutes" module have similar meanings, and the content under these two navigation categories is almost identical. Merging navigation bars of the same category can optimize information integration, help users reduce the identification of redundant information, improve the efficiency of accessing information under the corresponding category, and enhance user experience.

#### 5.2.6 Designing a comprehensive taxonomy

Systematic faceted system design in organizing information resources is particularly crucial in the maternal and child community, especially for platforms with information content services as their core functionality. Through reasonable faceted system design, effective support for users' information navigation can be achieved, reducing their cognitive costs and achieving the most effective connection between people and



information. The main methods of systematic faceted system design include those based on automatic clustering and automatic classification (Hearst, 2006). Research results indicate that the performance of combining well-designed faceted systems with automatic classification is superior to purely automatic clustering results. Users generally are not satisfied with the results of automatic clustering and are more willing to use pre-established and predictable faceted systems (English et al., 2001).

The maternal and child health information demand classification constructed in this study includes 6 dimensions, 15 subclasses, and 68 tertiary categories, comprehensively describing pregnant women's health information demand categories in maternal and child online forums. This serves as a reference for the design of information resource faceted systems in maternal and child online community forums. Additionally, based on empirical statistical results, sorting the tertiary classifications in the coding scheme can guide interface and interaction design, such as determining the sequence of navigation options.

#### 5.2.7 Structured information needs

Currently, the question-and-answer module in mother and baby community forums within online mobile applications lacks structured information input in its interaction design, resulting in users expressing their information needs with inconsistent and disorganized language structures. With the continuous growth of information, it is necessary to utilize machine assistance for the automation of user-generated content and information needs identification. However, text mining still faces significant challenges in semantic understanding and extracting information needs from contextual situations. Through the analysis of information needs characteristics, this study discovered that pregnant women involve many contextual elements when expressing their information needs, including personal situations, questioning motives, and desired information support.

In interaction design, guiding users to structurally express their information needs based on the analysis of these characteristics can better extract user information needs and continuously improve mother and baby health information services. For instance, in the "Doctor Q&A" module, users tend to ask doctors about physiological or abnormal symptoms experienced by themselves or their newborns. They seek answers regarding

the normalcy of these situations, the causes of symptoms, methods of relief and treatment, and whether a hospital visit is necessary to resolve their confusion and doubts.

When designing interactions for user inquiries, guiding users to describe their symptoms and select desired information support services, such as the reasons for symptom occurrence, intervention measures, and whether medical attention is required, can help users express their information needs more accurately. Through optimized interaction design, users can obtain more precise information services, while also assisting online doctors providing information support in better understanding user information needs, thereby enhancing communication efficiency.

## 6 CONCLUSION

### 6.1 Key findings

This study adopts both qualitative and quantitative research methods, integrating data from various sources to analyse the types of maternal and child health information needs, the types of information services provided by online mobile applications, and the gaps between maternal and child health information needs and services. The following conclusions are drawn:

In terms of analysis of the status of maternal and child health information needs, by analysing maternal and child health information needs in academic literature and online forums, six themes, fifteen subcategories, and sixty-eight tertiary categories were identified, further refining maternal and child health information needs based on previous research. Information needs regarding prenatal check-ups and newborn care received considerable attention in both data sources. Among the integrated subcategories of information needs, the highest demand intensity was for prenatal health care and disease prevention, followed by prenatal diet and nutrition needs, indicating the urgent need for pregnant women to focus on their health during pregnancy. On the other hand, information needs for infant education and maternity leave and labor protection had the lowest intensity. It was found that these two subcategories only appeared in academic literature, possibly due to their low TF-IDF values hindering the discovery of these needs in online forums.

Regarding analysis of the status of maternal and child health Information Services, by analysing the content of information services on online mobile applications, four categories, fifteen subcategories, and fifty-three tertiary categories were identified. The main health information service topics on the APPs were related to pregnant women, including prenatal physiological conditions and ailments, prenatal check-ups, prenatal daily life, prenatal daily health care and disease prevention, and prenatal diet and nutrition. Additionally, the APPs provided information on topics concerning fetuses and newborns that pregnant and postpartum women were concerned about, such as infant physiological conditions and prevention, fetal development, and feeding care. Furthermore, other maternal and child health information services covered topics related to pre-pregnancy, prenatal, postnatal, and infant education, including prenatal

preparation, postpartum confinement, labor knowledge, pre-pregnancy knowledge and precautions, and infant education.

With respect to analysis of the discrepancies between maternal and child health information needs and services a comparative analysis of maternal and child health information needs and service categories revealed significant disparities between the two. Information needs related to policies, work, and maternity leave were completely unmatched. Information needs for pre-pregnancy knowledge and precautions, prenatal check-ups, fetal development, prenatal preparation, feeding care, and infant education were only partially met, while most information needs for physiological conditions and ailments, diet and nutrition, daily health care and disease prevention, daily life, postpartum confinement, physiological conditions and prevention, and psychological adjustment were largely satisfied. After conducting differential analysis, this study proposes seven specific suggestions from the perspectives of specific information service content and the organization and implementation of software systems, which have important theoretical and practical significance for improving the services provided by information service providers.

## **6.2 Implications**

This study takes the "Maternal and Child Health Handbook" APP as an example to explore the information needs of a specific user group, pregnant women, for maternal and child health-related APPs, the current status of maternal and child health-related APP functions, and the differences between them. The study has profound theoretical and practical implications.

### **6.2.1 Theoretical implications**

This study uses content analysis, text mining and other research methods to objectively obtain maternal and child health information needs and information services by analysing the status of APP functions and relevant posts in online communities. This is helpful for providing theoretical basis for the development and optimization of maternal and child health-related APPs from the perspective of information needs.

### 6.2.2 Practice implications

For developers, identifying the differences between maternal and child health-related APP information services and information needs is conducive to improving the information service functions of the APP in a targeted manner, better meeting users' needs, and promoting the development of maternal and child health-related mobile APPs.

For users, with the continuous popularity of mobile communication devices, more and more users choose to obtain health information through APPs. Understanding the current status of maternal and child health-related APP functions and the differences between needs and services is helpful in helping users obtain higher-quality information services and better meet their maternal and child health information needs.

### 6.3 Limitations and future works

There are three limitations of this study. Firstly, there are relatively low quantity of academic literature used for content analysis: Despite numerous studies abroad on maternal and child health information needs and the availability of rich academic literature, there is still relatively low attention domestically in China, resulting in a limited number of academic references available for analysis.

Secondly, there might be potential omission of certain information needs. Due to the lack of a comprehensive professional terminology database for maternal and child health, there is a degree of subjectivity in preprocessing posts from online forums. Furthermore, selecting the top 250 keywords based on TF-IDF may overlook some less frequently occurring health information needs. Thirdly, there are some imitations on the study object. The types of information services are diverse, and this study only focused on the "Mother and Child Health Handbook" app as a data source for information services, neglecting other platforms such as (electronic) libraries, online websites, and other forms of information services, as it is impractical to cover all platform types.

To address the limitations and shortcomings of this study, future researchers could consider the following improvements. Firstly, subsequent research can broaden the dataset of information needs by selecting online forums or question-and-answer communities from other mobile applications. Secondly, alternative research methods

and algorithms, such as Latent Dirichlet Allocation (LDA) for topic modelling, could be explored to capture the themes of information needs. Thirdly, future studies could investigate different forms of maternal and child health information services and explore the differences between them. Through in-depth insights, these studies can provide compelling evidence for service providers striving to improve their services.

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