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Pregnancy eHealth and mHealth: user proportions and characteristics of pregnant women using Web-based information sources—a cross-sectional study

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Abstract
Purpose To analyze the current proportions and characteristics of women using Internet (eHealth) and smartphone (mHealth) based sources of information during pregnancy and to investigate the influence, this information-seeking behavior has on decision-making.
Methods A cross-sectional study was conducted at two major German university hospitals. Questionnaires covering socio-demographic data, medical data and details of Internet, and smartphone application use were administered to 220 pregnant women. Data analysis utilized descriptive statistics and multiple regression analysis.
Results 50.7 % of pregnant women were online information seekers. 22.4 % used an mHealth pregnancy application. Women using eHealth information showed no specific profile, while women using mHealth applications proved to be younger, were more likely to be in their first pregnancy, felt less healthy, and were more likely to be influenced by the retrieved information. Stepwise backward regression analysis explained 25.8 % of the variance of mHealth use. 80.5 % of cases were classified correctly by the identified predictors. All types of Web-based information correlated significantly with decision-making during pregnancy.
Conclusions Pregnant women frequently use the Internet and smartphone applications as a source of information. While Web usage was a common phenomenon, this study revealed specific characteristics of mHealth users during pregnancy. Improved, medically accurate smartphone applications might provide a way to specifically target the mHealth user group. As user influenceability was of major relevance to all types of information, all medical content should be carefully reviewed by a multidisciplinary board of medical specialists.

Keywords Pregnancy · eHealth · mHealth · Smartphone application · Internet · Obstetrics

Introduction

With the advent of the Internet as an important source of health information, *eHealth* has become a concept of growing importance. Eighty percent of US Internet users have sought healthcare information online, with birth and related topics being a main area of focus [1]. According to the European travel commission, Germany is among the top 5 countries in Europe in terms of the number of Internet users [2].

Women of reproductive age expecting a child are particularly frequent users of eHealth information [3, 4]. Pregnant women, primarily in the industrialized nations, are using the Internet, social media, and smartphone applications ("apps") in record numbers in search of health information on a wide range of obstetric and pediatric topics [5–7]. Furthermore, pregnant women using social media are not only seeking information online, but also

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sharing their knowledge with others through Internet forums [5, 8].

The term mobile health, or *mHealth*, encompasses the use of mobile telecommunication and multimedia and their incorporation into increasingly mobile and wireless healthcare delivery systems [9]. mHealth is defined as a medical and public health practice supported by mobile devices, such as mobile phones, patient monitoring devices, personal digital assistants, and other wireless devices [10]. The capabilities of these devices can be extended by the implementation of the so-called apps, which are end-user software products that are designed to be intuitive and do not require any training or specific knowledge [11].

Given the many digital health technologies that have recently emerged, including medical and health-related apps, little is known about how people are using these apps, whether the apparent benefits they promise are met and what their consequences may be [12–14]. On the one hand, mHealth offers obstetricians and midwives the potential to improve prenatal and maternal health outcomes by overcoming time and place barriers [9]. In particular, the period from conception to 4 weeks after childbirth represents a critical time window during which up to 75 % of maternal and 70 % of neonatal mortality could be averted through comprehensive and evidence-based interventions [15, 16]. On the other hand, another aspect to be considered is the risk of a negative impact on the interaction between patients and healthcare providers, which can lead to a lack of direct communication and in-depth information [17].

Additionally, careful consideration should be given to the fact that a significant portion of medical Web sites and the majority of smartphone mHealth applications are not transparent regarding the medical accuracy regarding of their health information [17]. The literature examining the impact of eHealth on the quality and safety of health care was found to be generally of substandard quality in a systematic review [18]. In another study conducted in 2001 on English-language Web sites with medical content, only 45 % of the clinical elements were minimally covered and completely accurate and only 24 % of the clinical elements were not covered at all [19]. Current data show that this has not yet improved significantly for the better [17, 18, 23]. As obstetrics remains the largest medico-legal liability in health care [20], we do not know who will be held liable if inaccurate Web-based information lead patients to misinformed decision-making.

Despite this potentially negative connotation, however, smartphones have also been shown to have positive medical aspects worthy of additional research. Therefore, several studies focusing on the use of eHealth and mHealth during the prenatal period have reported on benefits of mHealth monitoring systems in respect of, e.g., diabetic patients [21], adherence to antiviral therapy in patients with acquired immune deficiency syndrome (AIDS) [22], neonatal survival in resource-limited settings [24], smoking cessation during pregnancy [25], use as screening tools for depression [26], and healthier food choices [27]. A recent review also discussed the growing impact of patient–physician messaging as a convenient and time-saving tool [28].

However, research studies on the proportions and characteristics of women using eHealth and mHealth during pregnancy are sparse. Bauer et al. analyzed the use of mHealth in the primary care sector in the United States and concluded that the use of mHealth technologies was less common among older adults but common among other primary care patients, including those with limited health literacy and chronic conditions [29]. Only one very recent study focused on differences between eHealth and mHealth users in a small sample of pregnant women [30]. The authors observed that while there was a general willingness to participate in an mHealth intervention, willingness to participate in a mobile phone-based intervention tended to be increased especially in younger women and women who had no children at home [30].

Hence, very little is known about user proportions, characteristics of user groups, and the way in which online tools influence women's choices regarding medical care and pregnancy. Therefore, this study aimed to analyze the current Web and smartphone user proportions and characteristics among pregnant women and to investigate the influence on decision-making during pregnancy.

Methods

Study population

A cross-sectional, descriptive study was carried out among pregnant women who attended prenatal care at the University Hospitals of Heidelberg and Tübingen between January and August 2014, two perinatal centers of the highest level providing health services to low-, medium-, and high-risk obstetrical patients and performing approximately 4500 deliveries per year. Participants were recruited anonymously while waiting for their routine medical check-ups. The eligibility criteria included being 18 years or older and having a sufficient knowledge of the German language. For practical reasons, not all eligible women were invited to participate as recruitment only occurred on certain days of the week. In total, 283 German-speaking, randomly selected pregnant women were asked to complete the questionnaire, of whom 220 (77.7 %) agreed to participate. Their data were collected using a self-styled questionnaire, consisting of multiple-choice questions and short responses, developed and validated by an expert

panel of doctors and midwives. Ethics approval was granted by the Ethical Committees of the Universities of Heidelberg and Tübingen. After gaining ethical approval, a pilot feasibility study was carried out in ten women to assess logistic issues and to identify any data collection problems. No such problems were reported.

Outcome variables

The outcome variables were Internet and smartphone usage. All participants included in this study were asked "Do you use the Internet to retrieve information on pregnancy, delivery, or breastfeeding?". The question was repeated for smartphone usage. Responses were divided into four categories according to type and quality of the Web sites visited or smartphone applications used (1) smartphone usage of Internet and e-mail capabilities, (2) smartphone usage of health-related applications, (3) smartphone usage to communicate with healthcare specialists, and (4) no smartphone usage related to health information.

Exposure variables

The first part of the two-part questionnaire comprised 33 items covering both clinical (e.g., use of medication during the current pregnancy) as well as information on socio-demographic characteristics. Self-rated health as a global measure of quality of life [31] to determine health and well-being was assessed using a four-point Lickert-type scale. Response categories were "very good", "good", "fair", and "poor". Medical items included questions on previous pregnancies, mode of delivery, complications, preterm deliveries before week 37 of pregnancy, breastfeeding, intention to breastfeed after the current pregnancy, and medication.

Also surveyed was social capital, defined as the expected collective benefit derived from the preferential treatment and cooperation between individuals and groups, including economic and cultural resources [32]. Variables selected as potential measures of social capital included the following: general physical and psychological well-being (Cronbach's $\alpha = 0.65$), history of pregnancy termination, depression or anxiety disorders, social situation (Cronbach's $\alpha = 0.68$), worries about the future (Cronbach's $\alpha = 0.68$), and emotional and practical support from the woman's partner (Cronbach's $\alpha = 0.77$).

One additional item covered seven questions about the women's expectations and demands of the hospital where they wished to deliver and was entitled "expectations of the hospital of delivery".

The second part of the questionnaire comprised 13 items focusing on Internet usage for general purposes and as a specific source of information on pregnancy-related topics. This part included subitems on any specific aim for the search of pregnancy-related information and the type of information retrieved, the specific aim of the search for delivery-related information and the type of information found, the Web sources of pregnancy-related information, the attitude toward Web site search, and potential alternatives to Internet or smartphone usage. The impact of Web-based information on health choices during pregnancy was assessed by asking whether the information retrieved from the Internet influenced the women's decision-making during pregnancy. This was done using a four-point Lickert-type scale, the subitem being termed "influenceability".

Statistical analysis

All analyses were performed using the *Statistical Package for Social Sciences* (IBM® SPSS® v. 23.0.0.0). The valid number of cases n varied depending on the data subsets used for the particular test. All variables were not normally distributed (Kolmogorov–Smirnov test and/or Shapiro–Wilk test $P < 0.05$). Consequently, nonparametric tests were the method of choice to avoid lack of validity and robustness [33].

The main analyses included descriptive statistics and frequencies of eHealth and mHealth usage, group comparisons between the different user groups (χ^2 tests), and associations (Pearson correlations) with other study variables at all three measurement points. Generalized multiple ordinal logistic regression analysis was used to evaluate the independent contribution of the detected risk factors for each of the outcome variables. In all analyses, we set a conventional critical two-sided α error of $\alpha = 0.05$.

Results

Demographics

Of the 220 participants recruited into the study, 117 (53.2 %) were from the University of Heidelberg and 103 (46.8 %) from the University of Tübingen. Mean (SD, range) maternal age was 32.6 (5.0, 21–45) years, and mean gestational age (SD, range) was 33.3 (6.5, 5–42) weeks. The socio-demographic characteristics of the study population are summarized in Table 1.

There were 73 of 219 (33.3 %; denominator represents valid N cases) first-time pregnant women and 76 s-time pregnant women (34.7 %). A total of 70 women (31.9 %) were in their third or subsequent pregnancy. The pregnancy-related data are summarized in Table 2.

One-third of the pregnant women consulted a midwife (69 of 209 (valid N cases); 33.3 %) and 129 of 215 (60 %)

attended antenatal classes. Regarding Internet usage, 108 of 213 (50.7 %) women used medical Web sites to gather information on pregnancy. Mean (SD, range) time spent visiting Web sites was 2.38 (4.04, 0.02–30) h per week; 37 of 212 women (17.5 %) interacted with others through pregnancy-related forums. Mean (SD, range) time spent in forums was 3.41 (3.96, 0.25–16) h. A total of 47 of 210 (22.4 %) participants used smartphone applications with various pregnancy-related capabilities for a mean time (SD, range) of 1.52 (0.96, 0.30–3.00) h. A total of 34 of 210 women (16.2 %) used both the Internet (medical Web pages or forums) and smartphone applications. A total of 56 of 219 women (25.6 %) showed interest in a tailored healthcare provider-initiated pregnancy app.

Of 210 women (valid *N* cases), 123 (58.6 %) reported receiving pregnancy-related information from both physicians and midwives. As regards breastfeeding, 108 of 183 (59.0 %) women felt better informed by the midwives rather than doctors (6 of 183, 3.3 %). A total of 39 of 183 (21.3 %) women reported to be sufficiently well informed by both professional groups, while 30 of 183 (16.4 %) women stated still having questions that had remained unanswered by either of the above stakeholders.

Table 1 Socio-demographic sample characteristics (total $N = 220$)

	f	Valid (%)
Graduation		
No school-leaving qualification	1	0.5
Low secondary education	23	10.7
High secondary education	54	25.2
University entrance qualification	48	22.4
University degree	88	41.1
Total	214	100.0
Marital status		
Married and living together	172	79.6
Single and living together	37	17.1
Single and living alone	4	1.9
Divorced	3	1.4
Total	220	100.0
Level of employment		
Fulltime	61	28.4
Part-time (15–34 h)	34	15.8
Part-time (<15 h)	5	2.3
In training	6	2.8
Housewife	23	10.7
Unemployed	4	1.9
Temporary exempted	82	38.1
Total	215	100.0

Exploratory findings

Internet use: medical Web sites

We computed Spearman's ρ correlations to evaluate the association between parametric and ordinal study variables and medical Web site usage. The usage of medical Web sites was significantly associated with influenceability ($\rho = 0.40$, $P < 0.01$). The more pregnant women visited medical Web sites, the more they felt influenced by the information retrieved. Since there were no other significant correlations (see Table 3), we refrained from computing a regression model.

Internet use: Web forums

Maternal age ($\rho = -0.26$, $P < 0.01$), worries about the future ($\rho = -0.15$, $P = 0.03$) and influenceability ($\rho = 0.25$, $P < 0.01$) were significantly associated with the use of Web forums (see Table 3). To evaluate the independent contribution of the detected risk factors for each of

Table 2 Pregnancy-related characteristics (total $N = 220$)

	f	Valid (%)		*f*	Valid (%)
History of miscarriages/stillbirths			History of preterm births		
None	73	51.0	None	96	85.7
One	47	32.9	One	15	13.4
Two or more	23	16.1	Two or more	1	0.9
Total	143	100.0	Total	112	100.0
Desired mode of delivery			Intention to breastfeed		
Vaginal delivery	151	73.7	True	202	95.3
Cesarean section	54	26.3	False	10	4.7
Total	205	100.0	Total	212	100
History of peripartum depressive disorder			History of peripartum anxiety disorder		
True	16	7.6	True	25	11.7
False	194	92.3	False	188	88.3
Total	210	100.0	Total	213	100.0

Table 3 *P* values of Spearman's ρ correlations for eHealth and mHealth usage

	eHealth (medical Web pages)	Forums	mHealth (smartphone applications)
Maternal age	0.13	**<0.01**	**0.01**
Gestational age	0.59	0.46	0.15
Graduation	0.13	0.29	0.36
Self-rated health	0.64	0.74	**0.04**
Self-rated pregnancy-related level of knowledge	0.56	0.24	0.65
General wellbeing	0.49	0.34	0.61
Partner support	0.49	0.65	0.77
Social support	0.41	0.85	0.33
Worries about the future	0.55	**0.03**	0.81
Expectations of the delivery clinic	0.34	0.58	0.14
Influenceability	**<0.01**	**<0.01**	**<0.01**

All *P* values are two-tailed. Bold type indicates statistical significance

the outcome variables, we used multiple logistic regression analysis. Stepwise backward regression was chosen since forward regression analysis bears the risk of not selecting independent variables with small but meaningful effects. Maternal age was found to be the strongest explanatory variable of Web forum usage; a change in maternal age by 1 year increased or decreased the probability of using Web forums by a factor of 0.84 [odds ratio; 95 % confidence interval (CI) = (0.76; 0.93), $P < 0.01$]. In general, mean age (SD) of users was 29.8 (4.6) years while non-users were about 3 years older [33.2 (4.9)] years. Additionally, influenceability explained further variance in the use of Web forums; and a change in self-rated health by one response category increased or decreased the probability of using Web forums by a factor of 0.55 [odds ratio; 95 % CI = (0.31; 0.96), $P = 0.04$]. The final model explained 11.5 % (Cox & Snell) to 19.5 % (Nagelkerke) of variance. 84.7 % of cases were classified correctly by the explanatory variables.

Use of smartphone applications

We computed Spearman's ρ correlations to evaluate the association between parametric and ordinal study variables and smartphone application usage. Maternal age ($\rho = -0.23$, $P < 0.01$), self-rated health ($\rho = -0.14$, $P = 0.04$), and influenceability ($\rho = -0.24$, $P < 0.01$) were significantly associated with the use of smartphone applications (see Table 3). In addition, χ^2 tests were used for the analysis of associations (contingency coefficient φ) between nominal study variables and the outcome variable. χ^2 tests additionally revealed first-time pregnancies ($\varphi = -0.21$, $\chi^2 = 9.24$, $P < 0.01$), nulliparous women ($\varphi = -0.26$, $\chi^2 = 14.58$, $P < 0.01$), and peripartum depression ($\varphi = 0.16$, $\chi^2 = 5.27$, $P = 0.02$) to be factors correlated with the use of smartphone applications.

Table 4 Final logistic regression analysis model of smartphone application usage

Variable	*n* (%)	OR[a]	95 % CI[b]	*P*[a]
Maternal age	174 (100)	0.92	0.85–0.99	<0.05
Self-rated health	174 (100)	2.56	1.29–5.09	<0.01
Parity	113 (64.9)	3.68	1.59–8.51	<0.01
Influenceability	174 (100)	0.60	0.36–1.01	0.05

OR odds ratio, *95 % CI* 95 % confidence interval of odds ratio

[a] Empirical significance

Using multiple logistic regression analysis with backward procedure, maternal age, health status, parity, and influenceability remained in the final model (see Table 4). Users' mean (SD) age was 30.5 (4.8) years, and thus, they were 3 years younger than non-users whose mean age (SD) was 33.3 (4.8) years. Parity was revealed to be the strongest explanatory variable of smartphone application usage, followed by health status. If mothers were nulliparous, the probability of using mobile application increased by a factor of 3.675 (odds ratio). A change in self-rated health by one response category increased or decreased the probability of using smartphone applications by a factor of 2.560 (odds ratio). 17.0 % (Cox & Snell) to 25.8 % (Nagelkerke) of variance were explained by the final model. 80.5 % of cases were classified correctly by the explanatory variables.

Discussion

To our knowledge, this is the first study on Internet and smartphone application use among pregnant women in Germany. Web-based information-seeking behavior among pregnant women in Germany is a common phenomenon and not restricted to women with a specific profile. In our

study, 50.8 % of participants were frequent medical-related Internet users.

In general, our results support previous findings concerning the high frequency of online medical information seeking. Regarding the proportion of frequent Internet users, we observed a lower percentage than did other comparable European studies [5, 34]. This might be explained by a greater need for information during earlier stages of pregnancy. Kraschnewski et al. stated that the prenatal visit structure in many countries is not patient-centered, as women are offered too few routine obstetric visits during early pregnancy, the time when they have the most questions for their prenatal care providers [35]. Consequently, women turn to technology to fill their knowledge gaps. A Chinese study observed that the majority (81.5 %) of women consulted the Internet for information at the beginning of their pregnancy [7]. Another study from Italy reported similar results, with 72.4 % of participants consulting an online source during the first trimester [34]. Mean gestational age of our participants was 33.3 weeks of pregnancy, which could potentially contribute to decreased Internet usage.

Additionally, Internet use in our study did not correlate with any of the variables except influenceability. The more our participants resorted to online sources, the more they were influenced by the information they found there. This emphasizes the need for quality control of medical Web site content. In a study by Lagan et al. [36], two-thirds of the pregnant participants (63 %) reported that the information they retrieved from the Internet influenced their thinking about how their pregnancy and delivery should be managed. If decisions about the medical management during pregnancy are based on Internet information of poor quality, this could have negative implications for their own and the baby's health.

Regarding the sharing of health-related information with others, only 17.5 % of our participants engaged in Internet forums. Maternal age, worries about the future, and again influenceability were significantly associated with the use of online Web forums. Johnson stated in her research that Internet forums offer pregnant women and new mothers an extension of their social life and allow them to continue communicating with friends, even while being housebound or involved in domestic tasks specifically related to mothering [37]. As for the quality of information gathered in Internet forums, there are only very few studies, the majority of which showing that Internet forum users must be aware of the unreliability of information sources [38].

Smartphone pregnancy applications were used by 22.4 % of women participating in our study. In contrast to the widespread Internet use we observed, we found that women using smartphone applications were younger, were more likely to be in their first pregnancy, rated themselves as less healthy, and were influenced to a greater extent by the information they received. Stepwise backward regression analysis explained 25.8 % of variance and allowed 80.5 % of cases to be classified correctly by the identified predictors. Parity and self-rated health proved the strongest predictors of smartphone application use, a finding that adds a new perspective to the current body of literature.

Our results showed that characteristics of the mHealth group differed significantly from those of the eHealth group. Thus, the smartphone user group could be targeted specifically to fill medical knowledge gaps with the potential to improve pregnancy outcome. We also know from recent studies that mothers reporting fair or poor self-rated health are more likely to experience adverse pregnancy outcomes, e.g., preterm delivery [39, 40].

Our observation that especially nulliparous women use the new media as a source of information is also consistent with the recent literature. Studies have shown that women have their greatest need for information during their first pregnancy [7, 8]. The average number of children per woman in Germany was 1.47 in 2014 [41], which emphasizes the relevance and need for reliable information sources.

Our study showed the importance of influenceability, but unfortunately there is also evidence indicating that many Web sites and the majority of smartphone applications are not reliable sources of information. There are only very few published studies on this topic. In a study by Rezniczek et al. [23], only 4.2 % of 672 German-language gynecology Web sites they analyzed were rated as good. Bert et al. compared the most popular pregnancy applications and found that half of them contained no information on the content sources used, thus illustrating the major problem that app developer guidelines are lacking, even for medical applications [11]. As a result, women run the risk of letting misleading or conflicting information influence their decision-making.

Strengths and limitations

This study is the first quantitative research that has been undertaken to explore Internet and smartphone application use among pregnant women in Germany. It creates a foundation for further research. Particular strengths of this study include the revelation of specific characteristics of mHealth users during pregnancy and the discovery that all types of Web-based information significantly influence pregnant women in their decisions during pregnancy.

Nevertheless, a number of limitations should be considered when generalizing our results. As with most quantitative research, caution should be exercised when applying these data to other populations of pregnant women. The number of participants in the present study

was limited with $n = 220$, and the average educational level was higher, potentially resulting in greater health awareness. All patients were recruited at University Hospitals; therefore, more than the average of patients had a history of preterm birth (13.4 %) and a history of two or more miscarriages (16.1 %), which needs to be considered while generalizing our results to average populations of Community Hospitals. Despite the fact that our data demonstrated some convergence, it is possible that other opinions and perspectives were missed, and hence, the data potentially need to be interpreted with care and consideration. Additionally, factors such as self-rated health may depend on socioeconomic background, health awareness, and education, resulting in differences in variation between populations.

Conclusions

Pregnant women frequently use the Internet and smartphone applications as a source of information. While eHealth usage was a common phenomenon, this study revealed specific characteristics of mHealth users during pregnancy, including parity, lower self-rated health, younger maternal age, and influenceability, which create a strong incentive to resort to additional health tools. As user influenceability was of major relevance to all types of information, all medical content should be carefully reviewed by a multidisciplinary board of medical specialists. Improved, medically accurate smartphone applications might provide a way to specifically target the mHealth user group, thereby exploring its potential predictive ability to reduce adverse birth outcomes and prevent misguiding by non-evidence-based educational information. Therefore, developing high-quality medical mHealth applications and interventions represents a first important step as a key role for healthcare providers. As a future second step, patients need to be guided toward successful integration of these informative tools in their prenatal care.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interests.

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