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Original Paper

Acceptance Factors of Mobile Apps for Diabetes by Patients Aged 50 or Older: A Qualitative Study

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Abstract

Background: Mobile apps for people with diabetes offer great potential to support therapy management, increase therapy adherence, and reduce the probability of the occurrence of accompanying and secondary diseases. However, they are rarely used by elderly patients due to a lack of acceptance.

Objective: We investigated the question "Which factors influence the acceptance of diabetes apps among patients aged 50 or older?" Particular emphasis was placed on the current use of mobile devices/apps, acceptance-promoting/-inhibiting factors, features of a helpful diabetes app, and contact persons for technical questions. This qualitative study was the third of three substudies investigating factors influencing acceptance of diabetes apps among patients aged 50 or older.

Methods: Guided interviews were chosen in order to get a comprehensive insight into the subjective perspective of elderly diabetes patients. At the end of each interview, the patients tested two existing diabetes apps to reveal obstacles in (first) use.

Results: Altogether, 32 patients with diabetes were interviewed. The mean age was 68.8 years (SD 8.2). Of 32 participants, 15 (47%) knew apps, however only 2 (6%) had already used a diabetes app within their therapy. The reasons reported for being against the use of apps were a lack of additional benefits (4/8, 50%) compared to current therapy management, a lack of interoperability with other devices/apps (1/8, 12%), and no joy of use (1/8, 12%). The app test revealed the following main difficulties in use: nonintuitive understanding of the functionality of the apps (26/29, 90%), nonintuitive understanding of the menu navigation/labeling (19/29, 66%), font sizes and representations that were too small (14/29, 48%), and difficulties in recognizing and pressing touch-sensitive areas (14/29, 48%). Furthermore, the patients felt the apps lacked individually important functions (11/29, 38%), or felt the functions that were offered were unnecessary for their own therapy needs (10/29, 34%). The most important contents of a helpful diabetes app were reported as the ability to add remarks to measured values (9/28, 32%), the definition of thresholds for blood glucose values and highlighting deviating values (7/28, 25%), and a reminder feature for measurement/medication (7/28, 25%). The most important contact persons for technical questions were family members (19/31, 61%).

Conclusions: A lack of additional benefits and ease of use emerged as the key factors for the acceptance of diabetes apps among patients aged 50 or older. Furthermore, it has been shown that the needs of the investigated target group are highly heterogeneous due to varying previous knowledge, age, type of diabetes, and therapy. Therefore, a helpful diabetes app should be individually adaptable. Personal contact persons, especially during the initial phase of use, are of utmost importance to reduce the fear of data loss or erroneous data input, and to raise acceptance among this target group.

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KEYWORDS

mobile apps; mobile health; elderly; diabetes mellitus; blood sugar self-monitoring; patient acceptance of health care; qualitative research; guided interviews

Introduction

Numerous mobile apps exist that aim to support the self-management of patients with type 1 and type 2 diabetes. In addition to the documentation of blood glucose values, such apps are able to graphically depict those values, offer an analysis of trends, provide additional information about the disease, or to share relevant data with the attending physician [1]. Hence, they offer great potential to support therapy management, increase therapy adherence, and reduce the probability of accompanying and secondary disease occurrence.

Currently, 387 million people aged 20 to 79 years suffer from diabetes worldwide. This number is expected to rise to 205 million people by the year 2035. The prevalence of diabetes varies between the continents, with 5.1% in Africa and 11.4% in North America and the Caribbean [2]. The amount of undiagnosed cases is estimated to be between 27.1% and 53.6%. In 2014, 4.9 million people died from diabetes-related complications. In Germany, the country where this study was conducted, diabetes prevalence is currently at 9.0%, and more than 95.0% of those are suffering from type 2 diabetes [3]. This type of diabetes typically occurs at an advanced age and is the result of an interaction between genetic predisposition and environmental factors, especially physical inactivity, malnutrition, and the resulting obesity from these factors. The result is a decreased level of insulin action (ie, insulin resistance) and release. Contrary to type 2 diabetes, type 1 diabetes is an autoimmune disorder leading to decreased insulin release until there is a complete lack of insulin as a result of the destruction of the insulin-producing cells [4].

People aged 50 or older suffer disproportionately from diabetes mellitus, particularly type 2 diabetes [4]. However, as shown in the recently released Diabetes App Market Report, very few patients of this target group utilize diabetes apps to support their treatment [5]. Previous studies confirmed that the below-average utilization of such apps is caused by a lack of acceptance within the target group [5-10]. Therefore, we investigated the following question within the scope of our study: “Which factors influence the acceptance of diabetes apps among patients aged 50 or older?” We placed particular emphasis on the current usage of mobile devices and apps, acceptance-promoting/-inhibiting factors, features of a helpful diabetes app, and contact persons for technical questions. This study was the third of three substudies we conducted investigating the factors that influence acceptance among diabetes patients aged 50 or older. The two other accompanying substudies were previously published by Arnhold et al in April 2014 [1].

Several studies have focused on factors influencing the acceptance of technology, the most prominent being the Technology Acceptance Model (TAM) by Davis [11]. This model was used as a foundation for subsequent acceptance models and studies, due to its proven explanatory power. These subsequent models focused on individual target groups, technologies, or specific cases of application [6-10,12-16]. From there, new models and theories emerged, such as the Mobile Phone Technology Acceptance Model (MOPTAM) by Kwon and Chidambaram [17], the Unified Theory of Acceptance and Use of Technology (UTAUT) by Venkatesh et al [18], and the Senior Technology Acceptance and Adoption Model (STAM) by Renaud and van Biljon [19].

However, none of the previously developed models or studies examined the factors influencing the acceptance of mobile apps for diabetes among patients aged 50 or older. And in terms of the superordinate topic of acceptance of mobile health apps among patients aged 50 or older, only one related study was found at the time of preparing this article [16].

Therefore, we first had to test the existing models and their influencing factors against their applicability and relevance to the research questions investigated here. Additionally, we consulted studies, guidelines, and standards—International Organization for Standardization (ISO) and Deutsches Institut für Normung e.V. (DIN)—in the planning phase, taking into account their research foci, as shown in Multimedia Appendix 1 [20-47]. These studies helped provide the theoretical background for this study.

Methods

Overview

To investigate relevant acceptance factors, we chose the qualitative method of guided interviews, which added a qualitative dimension to the two prior quantitative substudies. Our aim was to understand the subjective perspective of older diabetes patients toward apps. We consciously opted for a personal approach with the study participants using personal interviews instead of questionnaires. This approach was used since a certain degree of insecurity toward the research topic was to be expected among the participants, due to a possible lack of previous experience. This approach enabled us to adapt the interview guideline according to the individual survey participants and their previous experiences in handling smartphones, tablets, and apps. Furthermore, the assessment of factors promoting or inhibiting the acceptance of diabetes apps by the elderly is a complex issue, and a qualitative approach was better suited to examine this topic. This study was approved by the Ethics Committee of the Technische Universität (TU) Dresden (reference number: EK 241072013), prior to the initiation of interviews. The interviews were conducted between July and December of 2013.

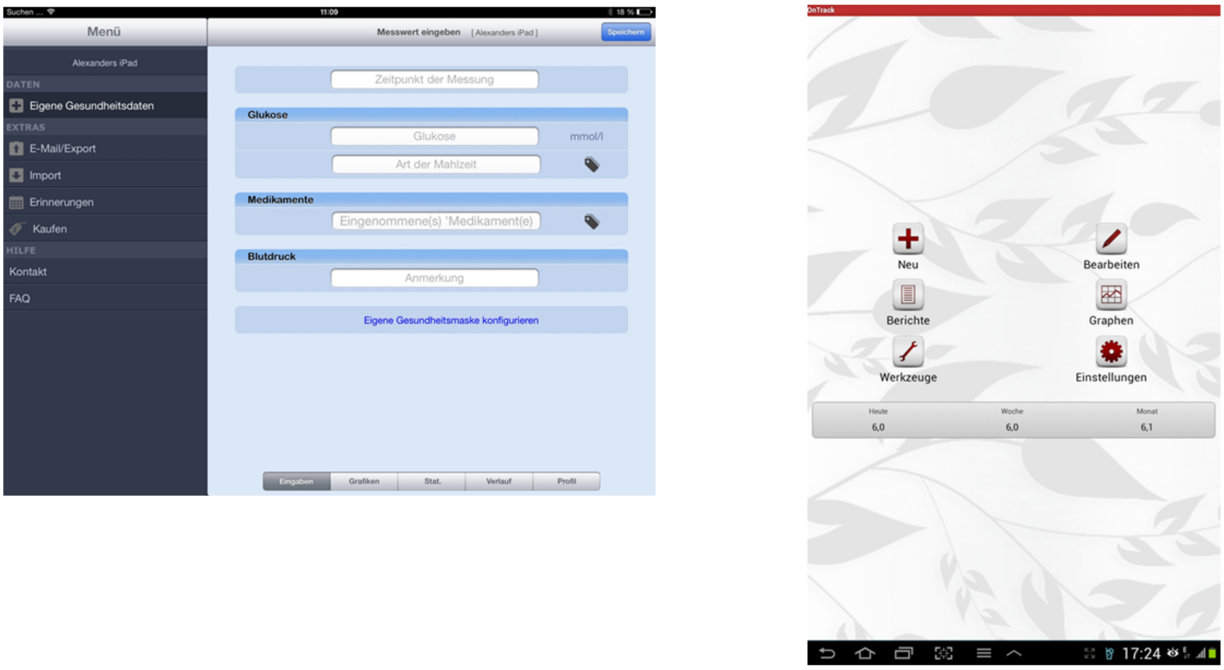
Interview Guideline

We developed a theory-based and uniform interview guideline with open-ended questions as a basis for the study (see Multimedia Appendix 2). It provided the foundation for the comparability of the answers. At the end of each interview, we asked the patients to test and evaluate two existing diabetes apps to reveal difficulties in (first) use:

1. *OnTrack Diabetes* version 2.8.8 (Medivo) for the Android 4.4.2 mobile operating system tested on a Samsung Galaxy Note 10.1.
2. *Glukose Monitor* version 2.7 (Taconic System LLC) for the iOS 7.0 mobile operating system tested on an iPad (4th generation).

The tested apps needed to satisfy the following criteria: (1) have German content, (2) be among the top 10 most commonly installed diabetes apps in the respective app store at the time of their selection (July 2013), and (3) be multifunctional (ie, able to combine several functions within one app). The following functions were offered by both apps: documentation function, analysis function, reminder function, and data forwarding/communication function. These functions are described in more detail in Arnhold et al [1]. Figure 1 shows screenshots of the start screens of both apps in order to illustrate their range of functions. In the run-up to the test, the participants did consciously not receive any form of introduction to the apps or the devices on which they were presented. The order in which the apps were presented was randomized to prevent an impact by the presentation order. Both apps were tested on tablets to increase the user-friendliness for the target group [48]. A pretest of the interview guidelines was performed prior to the commencement of the field work. Based on the results of the pretest, the guideline was slightly revised.

Figure 1. Screenshots of the start screens of the tested apps, Glukose Monitor (left) and OnTrack Diabetes (right).



Recruitment of Subjects

We decided to include both type 1 and type 2 diabetics in the study, as currently available apps address both types equally and rather differ in terms of the range of functions. Additionally, we included both participants with and without prior experience with mobile devices and apps to include the perspectives of both groups. The test subjects were recruited from diabetics' self-help groups, diabetics' associations, specialty shops for diabetics, general medical practices, diabetologists' practices, and pharmacies. The following inclusion criteria were defined: (1) aged 50 years or older, (2) diagnosed with type 1 or type 2 diabetes mellitus (via patients' self-disclosure), and (3) sufficient cognitive abilities to participate in a 60-minute interview. Persons who did not meet the inclusion criteria were excluded from this study.

Data Evaluation

All interviews were transcribed verbatim. The transcripts were the foundation upon which consecutive data analysis was performed. To analyze the data, we used the structured content analysis by Mayring [49], which allows for an association between the deductive and inductive creation of categories [49,50]. The analytical focus was on designing a system of categories and subcategories, as well as their characteristics [49], which in turn served as a structural dimension. We started the analysis in accordance with the structure of the guideline [50]. The interview questions were partially transcribed directly into analysis categories. Based on the content, all relevant text passages were extracted and put into their specific categories [50]. Developing the categorical system and the deductive category application represented the initial framework with which we structured the content and the analysis. During the process of examining and analyzing the individual interviews, we tested, modified, and specified the categorical system. Missing, but relevant, categories were developed and added inductively based on the text material that we collected. This was done up to the point at which the system became saturated (ie, no new categories emerged) [50]. This method complies with the principle of openness within qualitative research.

The chosen data collection method enabled us to quantitatively analyze the data due to its systematic and rule-based approach. The individual steps were processed with the qualitative data analysis (QDA) software MAXQDA (2011 version).

The following steps briefly explain the specifics of the method used for analyzing the gathered data:

1. We assigned individual categories to interview sections if the category was clearly relevant for a certain part of the interview, or if the relevance became clear in conjunction with other interview sections.
2. Within a single interview, each category was allocated only once. If a certain aspect was presented multiple times by a participant, it was considered as being mentioned only once to prevent the evaluation from being unbalanced.
3. Overall, we interviewed 32 people with diabetes. The method we chose allowed us to individually adapt the interview guideline to the actual interview, and to the aspects presented as most relevant by the participants. In turn, this resulted in interviews where we did not ask all possible questions, had some unanswered questions, or where unexpected statements were added by the participants themselves. Therefore, the previously mentioned sample of 32 participants is not necessarily equal to the number of interviews and answered questions used for data analysis. The sample number is equal, however, to the number of participants who addressed the individual topics.

Results

Overview

Overall, we interviewed 32 people with diabetes aged 50 or older. The recommended sample size for guided interviews is set at 30 people [51]. The interviews lasted between 15 and 90 minutes. The following represents a selection of the survey results. An overview of all results can be found in Multimedia Appendix 3.

Sociodemographics

There were an equal number of female (16/32, 50%) and male (16/32, 50%) participants in the interviews. The mean age of participants was 68.8 years (SD 8.2). Of all the participants, 44% (14/32) successfully completed vocational education, 13% (4/32) held a degree from a technical college, and 34% (11/32) had a university degree. Within their last or current job positions, 81% (26/32) had been working as employees, 13% (4/32) had been self-employed, and 6% (2/32) were employed as skilled workers. The majority of participants (17/32, 53%) were between 65 and 74 years of age. Of all the participants, 78% (25/32) have had diabetes mellitus for more than 10 years. Of the participants, 66% (21/32) had type 2 diabetes, 31% (10/32) had type 1 diabetes, and 1 patient out of 32 (3%) was afflicted with a hybrid form of both type 1 and type 2 diabetes.

Interest in New Technologies for Diabetes Treatment and Current Usage

Of all the participants, 34% (11/32) described themselves as highly interested in new technologies. Of the participants, 53% (17/32) were open-minded in terms of technology, provided that it entails an additional benefit to their treatment, such as having a positive effect on their therapy/blood glucose values or improved convenience of self-management. Only 13% (4/32) of the interviewed diabetics described themselves as having no interest in innovative technologies, whatsoever.

At the time of the survey, 25% (8/32) of the interviewed diabetics older than 50 years of age owned a smartphone or tablet and 47% (15/32) knew apps. However, only 2 diabetics out of 32 (6%) already used a diabetes app for the purpose of documentation of blood glucose values, namely the *OnTrack Diabetes* app for Android (Medivo) and the *DiabetesPlus für Typ 2-Diabetiker* app for Android and iOS (SquareMed Software GmbH).

Reasons Against Using Smartphones, Tablets, and Apps

Within this study, the essential aspects influencing the acceptance of diabetes apps were the self-reported reasons for or against the utilization of mobile devices and apps, as well as the obstacles that emerged during the actual app test. The following sections will describe the most influential factors in more detail.

We decided to consider the reasons against using a smartphone, tablet, and apps in one section, as the use of a portable device is the essential prerequisite to assessing apps. Additionally, the principles in handling these devices are similar. The main obstacles during the app test were a lack of additional benefits—for smartphones/tablets (10/18, 56%) and apps (4/8, 50%)—as well as finding the initial training and the handling phase for smartphones and tablets to be too complicated (6/18, 33%). One participant quoted the following:

> *As long as the alternative doesn´t provide me with a technical advantage or true advantage, I won´t put any efforts into mastering this, I mean, a smartphone requires a certain amount of practice, so yeah, I haven´t gotten around to doing this as I don´t see the personal advantage.* [Participant 2]

Out of 18 participants, 4 (22%) of them stated that the financial cost-to-benefit ratio of smartphones/tablets was unacceptable, especially when the device would only be used for diabetes treatment. Of 18 participants, 5 (28%) had concerns regarding the protection of their private data, as illustrated in the following quote:

> *...an inhibitional threshold where one could make a mistake and that data, personal data, could get lost, or that any involuntary payments might be necessary that were hidden somehow.* [Participant 1]

Additionally, the interviewed diabetics were concerned with a lack of interoperability between different devices and apps both for smartphones/tablets (2/18, 11%) and apps (1/8, 13%).

Issues Encountered During App Tests

In addition to the self-reported obstacles, an app test was conducted to determine obstacles during the actual practical use of mobile devices and apps, which in some cases was the very first contact with such technology. On average, the participants tested each of the two apps for 11 minutes (22 minutes in total).

Participants without previous experience spent more time on testing (26 minutes on average) compared to those who already used a smartphone or tablet (19 minutes on average). Figure 2 presents the most common obstacles. They were either observed by the interviewer or self-reported by the interviewees. Of the 32 participants, 3 (9%) were not able to participate in the app test section, as the interviews were conducted via telephone.

Out of the remaining 29 participants, 26 (90%) felt that neither functionality nor usability of the apps were intuitive or easy to grasp. This was especially true for those with no prior experience, who required additional aid (eg, how to enter data into the app). The following is an excerpt from transcript of the interview between interviewer and participant:

> *Would you spontaneously know what to do here? Hmm?* [Interviewer]
>
> *No, not spontaneously.* [Participant 5]
>
> *No?* [Interviewer]
>
> *Nope.* [Participant 5]
>
> *Could you enter data here by yourself?* [Interviewer]
>
> *No, but I should know how to do it.* [Participant 5]

Help was requested as to how to make the keyboard appear only after touching sections that ask for data to be entered, which wasn´t the case with previous generations of mobile devices. This is illustrated in the following interview excerpt:

> *And now, where to put this data?* [Participant 12]
>
> *It would go here. You are now supposed to touch here and then you can enter it.* [Interviewer]
>
> *Then the keyboard appears, hmm.* [Participant 12]

An additional difficulty was in understanding the symbols and functions of the keyboard, which were not intuitive and complicated the process of entering data even more. For the sake of completeness, it is important to mention that the difficulties encountered while using an onscreen keyboard cannot be counted as app-specific issues, as this may be the result of a lack of experience with smartphones and tablets, in general.

Of the 29 participants, 19 (66%) felt insecure and uncertain in terms of navigating through the menu within the apps, especially when switching between different layers of the menu. This is illustrated in the following interview excerpt:

> *If I want to go back, I´d simply have to click =.* [Participant 23]
>
> *Abort.* [Interviewer]
>
> *= ah on abort. Aha. And then again, again back or =.* [Participant 23]
>
> *Exactly. You can swype. If you want to go up.* [Interviewer]
>
> *= alright. So that´s how this works. This is a little different compared to my own.* [Participant 23]
>
> *Exactly.* [Interviewer]
>
> *There are keys or something, where I can go back or this arrow. Alright. This works by swype back and forth right?* [Participant 23]
>
> *Correct.* [Interviewer]

The participants faced issues such as adapting to different devices, operating systems (Android vs iOS), or apps and their individual layouts. This was particularly the case when attempting to save the progress on different devices, and this led to insecurity for 34% (10/29) of participants. Occasionally, it resulted in data loss. This issue is illustrated in the following interview excerpt:

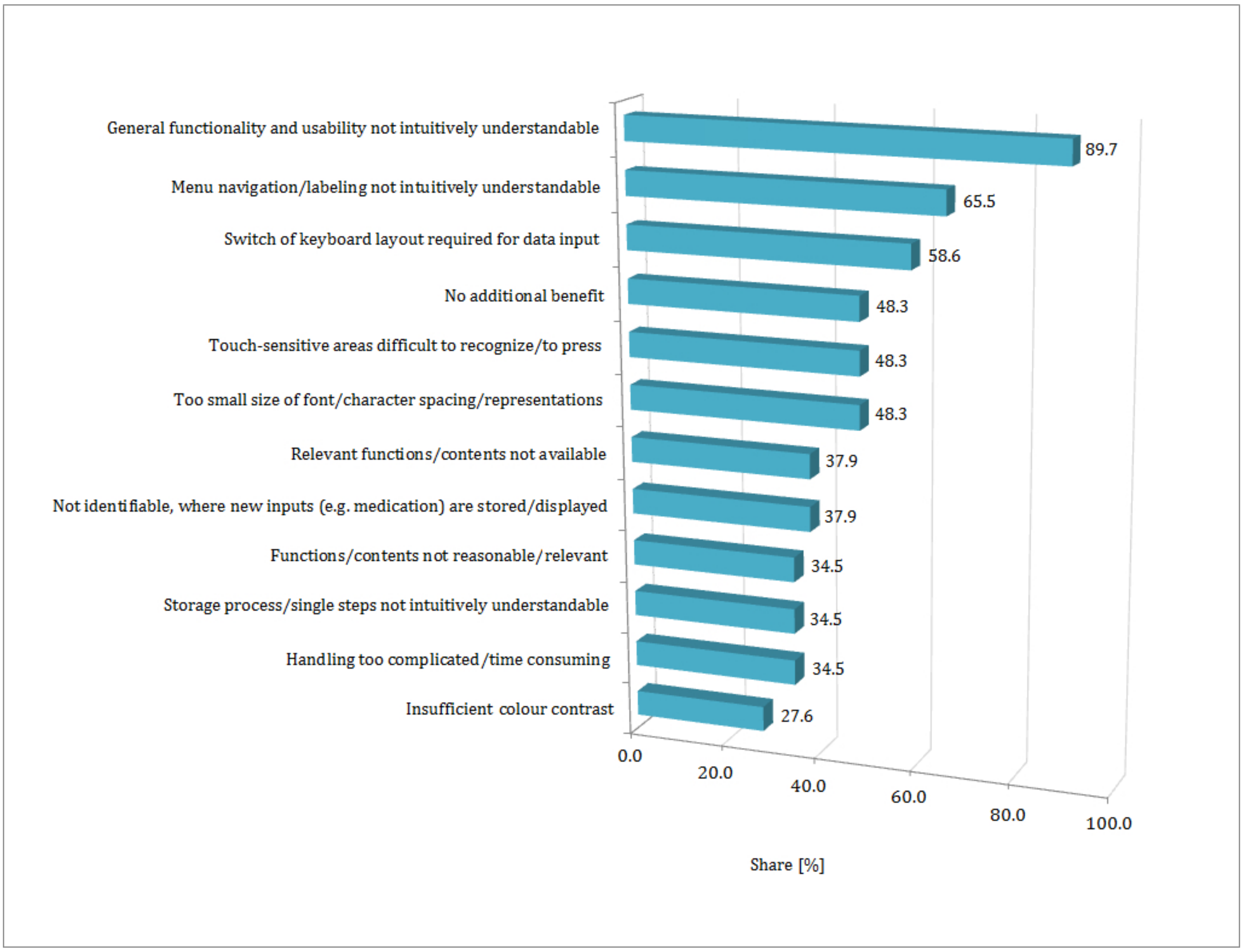
> *Now that I saved it, I must be able to find my data again. History? Now, I have also entered my medication. Where do I find this?* [Participant 1]
>
> *Well, you could try this up here, but ahm...* [Interviewer]
>
> *Well, they´re nowhere to be found. Did I forget to save them, I thought I had saved them?* [Participant 1]

Of 29 participants, 14 (48%) had difficulty in identifying and pressing touch-sensitive areas on the touchscreen. Another obstacle presented itself when users had to switch keyboard layouts, between numbers and letters, to enter data into the app. This also led to insecurity for 59% (17/29) of the participants. Criticism was also voiced about the small size of font, the space between letters and representations (14/29, 48%), the insufficient color contrast (8/29, 28%), and the inability to flexibly adapt the size of the font and representations to individual needs (4/29, 14%). Moreover, some of the participants felt that the options and possibilities of the presented apps did not fit their personal needs in terms of their diabetes treatment. They expressed that important functions were missing (11/29, 38%), for example, the possibility to manage polypharmacy or comorbidity. Some also had the impression that existing features were irrelevant (10/29, 34%). A medication-related issue is illustrated in the following interview excerpt:

> *Medicament. The thing is, the older you get the more of this and this is added...* [Participant 25]
>
> *Yes.* [Interviewer]
>
> *If so, then it would somehow have to be here.* [Participant 25]
>
> *The different drugs.* [Interviewer]
>
> *Yes.* [Participant 25]
>
> *(The) possibility to enter an annotation, so that one can enter insulin dosages. Especially when being physically active, to be able to leave out a dosage, the value, because of this, that is naturally a bit interactively presented...* [Participant 3]

Nearly half of all participants (14/29, 48%) repeatedly stated that neither of the two tested apps offered an additional benefit to their regular diabetes treatment. Of the participants, 34% (10/29) stated that it would be too difficult and time-consuming to obtain the skills required to work with this technology.

Figure 2. Issues encountered during app tests (multiple selections possible, n=29).



Positive Impressions During the Diabetes App Test

During the course of testing, the participants also reported positive impressions. Of 10 participants, 5 (50%) were of the opinion that using diabetes apps would have a positive effect on their self-reflection and the monitoring of their therapy. Of 10 participants, 2 (20%) were impressed by the clear arrangement and presentation of the entered data, as well as the simplicity and speed of the documentation. Both patient groups, those with and those without prior experience in using smartphones and tablets, reported positive impressions.

Features and Design of a Useful Diabetes App

In the course of this survey, we asked the participants what features they would expect to find in a helpful diabetes app (ie, which features would entail individual additional value). Of 28 participants, 9 (32%) expressed their need to be able to add personal remarks to the measured blood glucose values (see Figure 3). They said this would be useful should it be necessary to recreate the situation under which data was aggregated (ie, extremely low or high blood glucose values). A quarter of the participants (7/28, 25%) said they would appreciate a reminder feature for medication or blood glucose measurement. The same number of participants (7/28, 25%) felt that it would be useful to be able to define individual thresholds for blood glucose values and to be able to highlight deviating values. This is illustrated in the following quote:

> *It might be highlighted, if it is above or below, so that this here, if it is dangerous, is red and the rest could be yellow or something, so that I say, "Aha. That´s green, normal." Just like a traffic light. Red, danger, and yellow is for or it decreases. Well. That would be good.* [Participant 14]

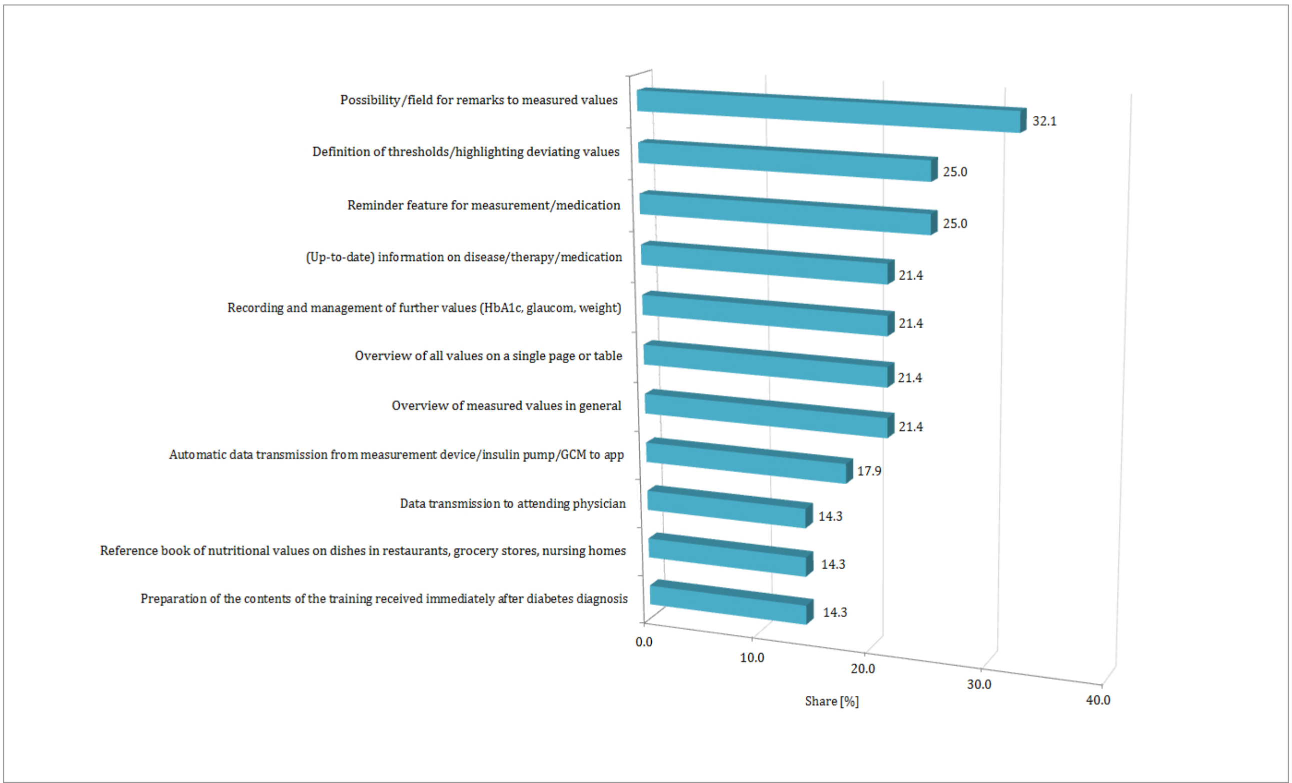
Of 28 participants, 6 (21%) would like to find a kind of reference book in which to look up information about diabetes mellitus, its treatment, and medication. Furthermore, they would appreciate finding information regarding nutritional facts for meals, which one would consume in a restaurant, or meals that have not been prepared by oneself (4/28, 14%). In order to support the documentation of values, participants would prefer to find all information (ie, blood glucose values, medication, and annotations) on a single page or table (6/28, 21%). This reveals their perception and preference of already existing and utilized blood glucose diaries. This is illustrated in the following quote:

> *You know, not that I have to click here again and another table (appears), and something else. And here, I know, with this small piece (authors note: patient presents blood glucose diary), I have the overview. If such a table would be in here I wouldn´t object to it.* [Participant 6]

Altogether, the tested apps did not provide any of the features the patients would expect to find in a helpful diabetes app, except for the reminder feature.

In addition to distinctive features, characteristics of the design of an app are crucial for their acceptance and usage among diabetics 50 years and older. The special usability requirements provided by elderly users of mobile apps have been presented and evaluated by Arnhold et al [1].

Figure 3. Ideas and needs for new diabetes apps (multiple selections possible, n=28).



Contact Persons for Technical Questions

For questions related to using modern technology—in general, or specifically for diabetes treatment—family members were the primary choice for 61% (19/31) of the participants, particularly their children, grandchildren, and partners. The second most frequently asked group of people were friends or people from their peer group (11/31, 35%). The least favorite source for information was the Internet or online forums used to provide solutions for technical difficulties (2/31, 6%).

Discussion

Principal Findings

Previous Knowledge and Experiences: Secondary Impact Factor

Regarding the treatment of diabetes patients aged 50 or older, apps only played a minor role among the participants. Only 2 out of 32 (6%) of the interviewees had already used diabetes apps. The Diabetes App Market Report [5] published in 2014 also illustrates that the affected patients accept and utilize diabetes apps rather restrainedly. Although the overall percentage (8/32, 25%) of smartphone and tablet users was significantly higher, it was still lower than that of neighboring countries such as Switzerland, where 52.0% of 55- to 69-year-olds are using this technology [52]. Even without consideration of age, Germany is far behind in the use of smartphones compared to Spain, Italy, Canada, the US, or the United Kingdom [53,54]. The survey showed that a lack of experience with handling smartphones and tablets minimizes the intention of using apps. However, increasing smartphone penetration will lead to a considerable increase in the experience of the target group (ie, those aged 50 or older) in handling such devices. Therefore, this obstacle for using those apps can be expected to diminish in the future.

Perceived Ease of Use: Main Impact Factor

The elderly have notably different requirements in terms of the handling of mobile apps compared to younger people. These have been presented, as well as evaluated, in the two previous substudies [1]. Taking those different usability requirements into consideration will immediately and positively impact the perceived ease of use [1]. As part of the survey, the app test showed that disregarding those usability requirements will result in the greatest impediment when (first) using the apps. The surveyed participants did not intuitively grasp the concept of how to execute the first steps (during first use). There were difficulties concerning the understanding of the menu guidance and navigation, the menu labelling, and the recognition of touch-sensitive areas of the screen. Additionally, barriers to ease of utilization were fonts and representations that were too small, as well as color contrast that was too low or absent. The obvious shortcomings in user friendliness of recently available apps for patients aged 50 or older have also been shown in studies by Arnhold et al [1], Schmid et al [16], and Grindrod et al [55]. However, even if apps reach a high degree of usability, it does not necessarily mean that elderly users will use the app intensively on a long-term basis within the scope of their therapy.

Perceived Additional Benefit: Main Impact Factor

Another main impact factor the study revealed was the perceived additional benefit for diabetes patients aged 50 or older. Therefore, it confirmed results of former studies regarding the acceptance of technology [16,18,39,55-57]. In conjunction with the perceived ease of use, these are the dominating impact factors on the acceptance of technology, both in the former studies and in this study. The lack of additional benefits is a considerable impact factor, which was revealed during the use of smartphones and tablets, as well as apps. This indicates that diabetes patients aged 50 or older are not sufficiently aware of the advantages provided by the apps when compared to previous types and methods of therapy management. Grindrod et al [55] have shown the same results within their usability study evaluating the perceptions of older adults concerning mobile medication management apps. Therefore, a diabetes app must provide clear benefits in comparison to conventional blood glucose diaries in written form (eg, for documenting purposes). Both types of documentation serve a practical purpose when being on the way, but several helpful functions were suggested that only a diabetes app could deliver: a reminder feature for medication/measurement, the definition of thresholds and the highlighting of deviating values, (current) information on disease/therapy/medication, and an automatic and wireless transmission of blood glucose data from the measurement device to the app or to the attending physician. These functions are similar to those that were found to be helpful in studies by Lorenz and Oppermann [9], Mallenius et al [8], and Schmid et al [16].

The target group of diabetes patients aged 50 or older is a rather heterogeneous one. For that reason, it is impossible to address the needs of all diabetes patients adequately with one diabetes app in order to gain an additional benefit. This was also shown during the survey. Specific functions of the tested apps were found to be irrelevant, or individually important ones were missing. Because of this, it is vital to take a modular and individually adjustable approach when developing and programming an app. Numerous studies also verified this to be a crucial aspect to app development [7,9,16,55]. Another possibility would be the implementation of autodidactic modules in an app, following and adapting to the learning process of the user.

Current State of Health: Secondary Impact Factor

The perceived additional benefit is closely linked to both the current state of health and the need for support (see section on perceived additional benefit). Accordingly, there are groups of patients that gain considerably more additional benefit by app usage compared to others. For instance, the effort of measurement, medication, and documentation presents a much bigger obstacle for diabetics with insulin therapy than for those who are treated with oral antidiabetics. It could be very useful to simplify and optimize these tasks with an electronic data transfer, graphical illustrations, or trend analysis. An additional option is the use of apps that support recently diagnosed type 2 diabetics, apps that can give information regarding the disease and therapy, and provide aid on how to change habits. In the best case scenario, this strategy could delay the beginning of a medical treatment. For this area of application, it would be sensible to have apps that could autonomously adapt to the needs of their users. This has been shown by Schmid et al [16], in which health apps that help manage daily therapy tasks and support health were found to be useful. Therefore, the results of this survey show the possible influence of health status on the additional benefit and, consequently, the acceptance of the technology.

Until now, with very few exceptions [58], there is a lack of well-directed integration of apps into individual treatment planning. The reason for that is the nonexistence of binding regulations in terms of documentation requirements, liability, and invoicing amongst attending physicians. Additionally, questions remain concerning insufficient interoperability and the integration of gathered data into health care systems [59,60].

Available Support: Secondary Impact Factor

When finding answers to questions regarding technology, a personal contact person plays a central role for diabetes patients aged 50 or older. The first choices for help were family members, especially children and grandchildren, followed by acquaintances and friends, the local distributor, and the attending physician. The importance of the family and acquaintances was demonstrated in a study by Mallenius et al [8]. The collection of information via the Internet, operating instructions, or service hotlines hardly played a role. Thus, if one tries to increase acceptance in the target group of diabetes patients aged 50 or older, there should be a personal introduction and a contact person in attendance during the initial phase of use (eg, the Amazon Mayday service). The results of this survey are supported by similar results from the MOBILE.OLD project [61] and by Schmid et al [16].

Trust in Own Technical Abilities/Insecurities in Utilization, Perceived Data Security, and Expected Reliability/Fault Tolerance: Secondary Impact Factors

Personal contact persons can have an advisory and clarifying role in terms of helping with diffuse insecurities in technology utilization. This survey showed that diabetes patients aged 50 or older fear data loss, insufficient data protection, and, especially, erroneous data input and its consequences. Taking into account that diabetes apps are dealing with health-related data, their fear is justified. The study by Schmid et al showed that the reliability of mobile apps is an essential acceptance factor. Thus, concerns regarding data security have a negative impact on acceptance [16]. The guarantee of data protection in cases of apps is a current key issue at the European and international level. Extensive attempts aim at defining, harmonizing, and implementing binding quality standards and regulations of certification [60].

Joy of Use: Secondary Impact Factor

Generally, the results of the survey showed that people with diabetes aged 50 or older are very open-minded regarding technology, thereby confirming the results of the investigations by Renaud and Biljon [19] and Steele et al [10]. Simultaneously, the reasons against the utilization of smartphones, tablets, and apps were collectively described as an "absence of joy of use." This agrees with the results from studies by Kwon and Chidambaram [17], Conci et al [14], and Schmid et al [16]. For instance, the implementation of playful elements (ie, gamification) can increase pleasure and motivation during the utilization of the app. However, until now only a few diabetes apps make use of these elements, as shown by the Diabetes App Market Report [5].

Limitations

When interviewing study participants, there is always the possibility that their answers are influenced by social desirability, which in turn could lead to biased results. To tackle this issue, we opted for an open interview setting, gave participants the chance to ask questions, and kept the number of people present during the interview to a minimum.

The choice of guided interviews as the method for our data collection was done with regard to an open interview setting and the chance to ask further targeted questions, in case particularly interesting or relevant topics arose. However, we restricted the evaluation of the gathered data to the unambiguous statements provided by participants during the interview. Naturally, we could not have drawn any conclusions on aspects and needs that might be relevant to the participants, but were not presented to us.

Strengths

At the time of preparing this article, there were no other studies investigating the acceptance of diabetes apps by patients aged 50 or older. Hence, this study makes an essential contribution toward a better understanding of the promoting and inhibiting factors that influence the acceptance and usage of diabetes apps. We consciously decided to use a qualitative research method in order to have an open approach toward this field of research, and to put focus on the relevant subjective aspects of the participants. In combination with the work by Arnhold et al [1], it is now possible to conceptualize diabetes apps that are tailored to the needs, skills, and usability requirements of the target group, diabetics aged 50 or older. In addition, the results can be used as a starting point for quantitative studies in this field with a larger sample size.

Conclusions

This study was the first to examine the factors that have an impact on the acceptance of mobile diabetes apps by patients aged 50 or older. The key factors that emerged for acceptance were the perceived additional benefit and the perceived ease of use. Less influential factors were previous experiences/knowledge, current health status, available support, trust in own technical abilities, perceived data security, expected reliability/fault tolerance, and joy of use. Furthermore, we showed that the needs of the investigated target group are highly heterogeneous due to differences in previous knowledge, age, type of diabetes, and therapy. Therefore, the contents of a helpful diabetes app should be individually adaptable. Personal contact persons, especially during the initial phase of use, are of utmost importance to reduce the fear of data loss or erroneous data input, and to raise acceptance among this target group.

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Conflicts of Interest

None declared.

Multimedia Appendix 1

Overview of consulted studies related to the acceptance factors for diabetes apps.

[PDF File (Adobe PDF File), 23KB - med20_v4i1e1_app1.pdf]

Multimedia Appendix 2

Interview guideline.

[PDF File (Adobe PDF File), 21KB - med20_v4i1e1_app2.pdf]

Multimedia Appendix 3

Overview of interview results.

[XLSX File (Microsoft Excel File), 40KB - med20_v4i1e1_app3.xlsx]

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Abbreviations

DIN: Deutsches Institut für Normung e.V.
ISO: International Organization for Standardization
MOPTAM: Mobile Phone Technology Acceptance Model
QDA: qualitative data analysis
STAM: Senior Technology Acceptance and Adoption Model
TAM: Technology Acceptance Model
TU: Technische Universität
UTAUT: Unified Theory of Acceptance and Use of Technology

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Original Paper

Web 2.0 Applications in Medicine: Trends and Topics in the Literature

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Abstract

Background: The World Wide Web has changed research habits, and these changes were further expanded when "Web 2.0" became popular in 2005. Bibliometrics is a helpful tool used for describing patterns of publication, for interpreting progression over time, and the geographical distribution of research in a given field. Few studies employing bibliometrics, however, have been carried out on the correlative nature of scientific literature and Web 2.0.

Objective: The aim of this bibliometric analysis was to provide an overview of Web 2.0 implications in the biomedical literature. The objectives were to assess the growth rate of literature, key journals, authors, and country contributions, and to evaluate whether the various Web 2.0 applications were expressed within this biomedical literature, and if so, how.

Methods: A specific query with keywords chosen to be representative of Web 2.0 applications was built for the PubMed database. Articles related to Web 2.0 were downloaded in Extensible Markup Language (XML) and were processed through developed hypertext preprocessor (PHP) scripts, then imported to Microsoft Excel 2010 for data processing.

Results: A total of 1347 articles were included in this study. The number of articles related to Web 2.0 has been increasing from 2002 to 2012 (average annual growth rate was 106.3% with a maximum of 333% in 2005). The United States was by far the predominant country for authors, with 514 articles (54.0%; 514/952). The second and third most productive countries were the United Kingdom and Australia, with 87 (9.1%; 87/952) and 44 articles (4.6%; 44/952), respectively. Distribution of number of articles per author showed that the core population of researchers working on Web 2.0 in the medical field could be estimated at approximately 75. In total, 614 journals were identified during this analysis. Using Bradford's law, 27 core journals were identified, among which three (Studies in Health Technology and Informatics, Journal of Medical Internet Research, and Nucleic Acids Research) produced more than 35 articles related to Web 2.0 over the period studied. A total of 274 words in the field of Web 2.0 were found after manual sorting of the 15,878 words appearing in title and abstract fields for articles. Word frequency analysis reveals "blog" as the most recurrent, followed by "wiki", "Web 2.0", "social media", "Facebook", "social networks", "blogger", "cloud computing", "Twitter", and "blogging". All categories of Web 2.0 applications were found, indicating the successful integration of Web 2.0 into the biomedical field.

Conclusions: This study shows that the biomedical community is engaged in the use of Web 2.0 and confirms its high level of interest in these tools. Therefore, changes in the ways researchers use information seem to be far from over.

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KEYWORDS

Social media; Internet; Health information management; bibliometrics; Medline; Blogging; Medical Informatics

Introduction

Over the past two decades, the World Wide Web has changed researchers' habits. These changes were further expanded when "Web 2.0" became popular in 2005 [1], providing tools and platforms that facilitate user collaboration, user-generated content, and data sharing. These tools have gradually influenced the world of research [2,3], especially in biology and medicine [4-9], and their use is increasingly common, notably with the arrival of "digital natives" in laboratories [10,11].

Bibliometrics is a helpful and widely used tool for describing patterns of publication and interpreting temporal evolutions and the geographical distribution of research in a given field. However, few studies employing bibliometrics have been carried out on the correlative nature of scientific literature and Web 2.0. A bibliometric analysis was performed in 2009 by Chu and Xu [12] on a set of 1718 documents relating to Web 2.0 using several databases. It was found that Web 2.0 is a rapidly developing area, with medicine and sociology being the major contributing disciplines to the scholarly publications. In 2011, Aharony [13] performed a statistical descriptive analysis and a thorough content analysis of descriptors and journal titles in the field of library and information science in a study of 472 articles. They focused on the subject of Web 2.0 and its main applications. Main findings revealed that the percentage of articles related to Web 2.0 was low, and showed a close link between Web 2.0 and library topics. In the field of medicine, Van De Belt et al [6] performed a systematic literature review in 2010 of electronic databases (PubMed, Scopus, CINAHL) and gray literature on the Internet using search engines to identify unique definitions of Health 2.0/Medicine 2.0 and recurrent topics within the definitions. The analysis was done on 1937 documents and they concluded that Health 2.0/Medicine 2.0 were still developing areas, and that there was still no general consensus regarding the definition of Health 2.0/Medicine 2.0.

The aim of the present study was to provide an overview of Web 2.0 implications in the biomedical literature and to answer the following questions: What is the growth rate of biomedical literature on Web 2.0?; What are the key publications, countries, and authors in the field?; Which Web 2.0 terms are the most recurrent in biomedical literature?; and, Are the various applications of Web 2.0 expressed in the biomedical literature? Established bibliometric methods have been used to perform the present study. One example is the identification of core journals using Bradford's law of scattering which has, to the best of our knowledge, never been done to study literature related to Web 2.0.

Methods

The search for papers to be included in this study was carried out on February 7, 2013, using the PubMed database [14], developed by the National Center for Biotechnology Information (NCBI) at the National Library of Medicine (NLM). Keywords used in the search were chosen since they were known to be representative of Web 2.0 applications [7,12,13,15]. Search strategy was built around identifying keywords in medical subject headings (MeSH) and completed, in the absence of results, by a text search in the title and abstract fields. When necessary, keywords were accompanied by a truncation to bring in all possible variants. The study was limited to original research articles corresponding to "Journal articles" shown under the "Publication type" field.

The final search strategy was the following: ("social networking"[MeSH Terms] AND (web [Title/Abstract] OR internet [Title/Abstract])) OR ("web 2.0" [Title/abstract] OR "Medicine 2.0" [Title/abstract] OR "Health 2.0" [Title/abstract] OR "Biology 2.0" [Title/abstract] OR "science 2.0" [Title/abstract] OR Social Media [MH] OR Syndication [Title/Abstract] OR wiki [Title/Abstract] OR Blogging [MeSH Terms] OR blog* [Title/Abstract] OR microblogg* [Title/Abstract] OR Cloud computing [Title/Abstract] OR folksonom* [Title/Abstract] OR social bookmark* [Title/Abstract]) AND (1951:2012 [DP]) AND (journal article [PT]), where MeSH stands for "Medical Subject Headings", DP "Date of Publication", and PT "Publication Type".

Data downloaded from PubMed in Extensible Markup Language (XML) were processed through developed hypertext preprocessor language (PHP) scripts, then were imported to Microsoft Excel 2010. All articles were manually reviewed by the author of this article and those not related to Web 2.0 were eliminated. When no abstract was available for a reference, PubMed "Related citations" were consulted to determine the eligibility of the article in the present study.

Microsoft Excel served for assessing the growth of literature, for journals, language of publication, authorship pattern, and number of publications per country. The average yearly growth rate was calculated as the mean percentage of annual growth for the period studied, with average yearly growth rate=(Current year total - Previous year total)/Previous year total [16,17].

Average yearly growth rate and percentage of articles published in English were also calculated for the whole PubMed database for the period 2002-2012. This period was chosen because it corresponds to the period where articles related to Web 2.0 were found in this study.

Bradford's law of scattering has been used extensively in the information science literature to describe the dispersion of articles in any scientific field [18] and to identify core journals of serial titles [16,19,20]. Bradford's law states that "if scientific journals are arranged in order of decreasing productivity of articles on a given subject, they may be divided into a nucleus of periodicals more particularly devoted to the subject and several groups or zones containing the same number of articles as the nucleus, when the numbers of periodicals in the nucleus and succeeding zones will be as 1: n : n^2" [21]. This means that "Bradford's law predicts that the number of journals in the second and third zones will be n and n^2 times larger than the first zone respectively, and therefore, it should be possible to predict the total number of journals containing articles on a subject once the number in the core and middle zone of journals is known" [22]. To identify the core journals and predict the number of journals containing articles related to Web 2.0, we applied Bradford's law by dividing the publication frequency ranked journals into three groups, with each group containing approximately the same number of articles.

The Journal Citation Reports (Thomson Reuters) was used for Impact Factor determination. For the determination of affiliation of authors, England, Scotland, Northern Ireland, and Wales were clustered into the United Kingdom. Words from both title and abstract fields were recovered for keyword frequency calculation using TextSTAT 2.9 software [23]. Words or expressions were manually sorted to extract those relating to Web 2.0. Similar words—differing by the singular/plural, upper/lower case—were aggregated (eg, wiki/wikis, facebook/Facebook). Words thus obtained were manually sorted into eight categories: one general category and seven others corresponding to blog, cloud computing, microblogging, social bookmarking/document sharing, social network, syndication, and wiki.

Results

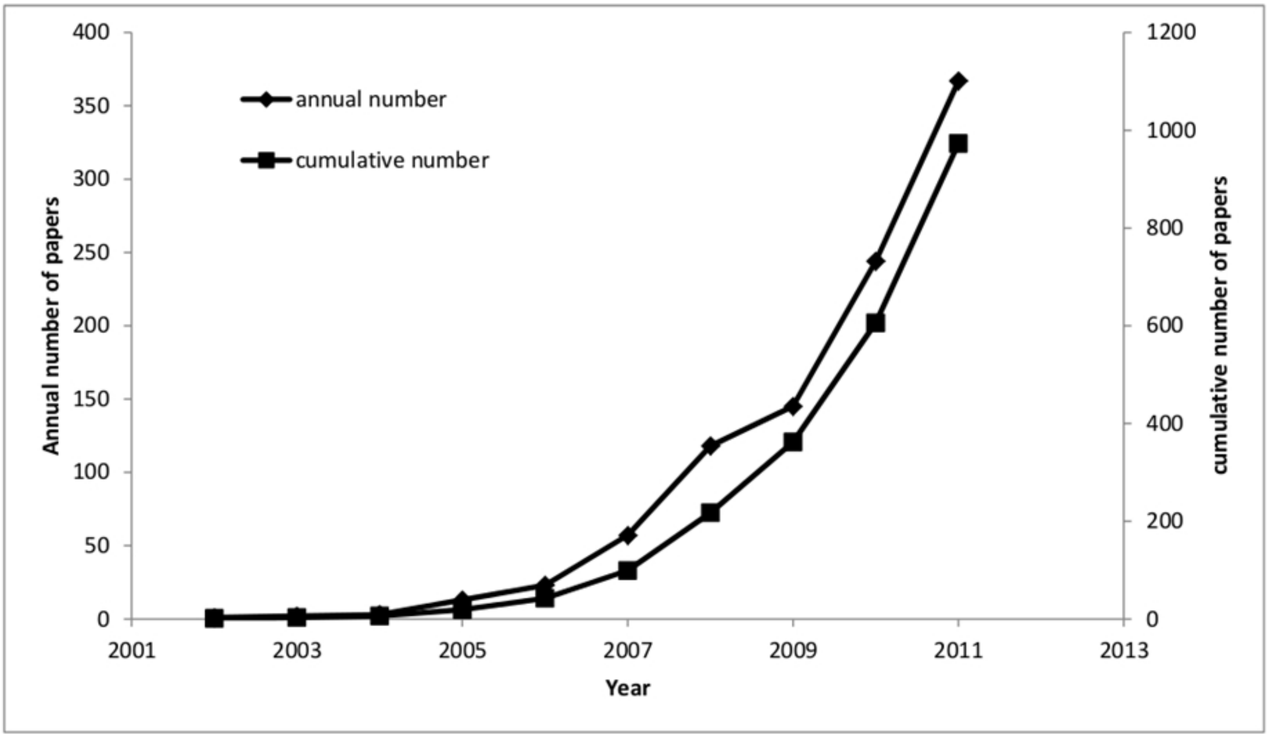
Overview

The publication search turned in a total of 1578 references. After manual sorting and elimination of inappropriate references, 1347 articles were retained for inclusion in the study.

Growth of Literature

As shown in Figure 1, Web 2.0 references, starting in 2002 with one article, had risen to 1000 per year by 2009 and continued to grow throughout 2011 (2012, being incomplete, is not represented). The average annual growth rate for the period 2002-2011 was 106.30% for Web 2.0 related articles, and 6.27% for the whole PubMed database for the same period.

Figure 1. Growth of literature (annual number and cumulative number).



Journals

A total of 614 journals were identified during this analysis. As shown in Figure 2 and Table 1, one-third of the published articles were found in a mere 27 journals (27/614; 4.4%). This first third represents the journals that published the most articles (between 7 and 53 articles on the period studied) and that are presumed to be of highest interest for researchers interested in Web 2.0 ("core journals"). The middle third corresponds to the journals (178/614; 29.0% of journals) that published an average amount of articles, and the last third includes the "long tail" of journals (409/614; 66.6% of journals) that published one article and must be regarded as being of least importance. The theoretical ratio of number of journals (43.4) and the theoretical number of journals in the last third (1172) were higher than the values obtained experimentally (15.1 and 409, respectively).

Table 2 presents the 38 journals that have published more than six articles and their Impact Factor (IF) when available.

Table 1. Bradford zones of scattering for Web 2.0 literature.

Zones	Number of journals	Percentage of journals	Number of articles	Cumulative number of articles (%)	Description	Ratio (number of journals)	Theoretical ratio (1:n:n^2)	Theoretical number of journals
Core journals	27	4.4%	428	428 (31.7)	Producing <53 and ≥7 articles	1	1	27
Middle	178	29.0%	510	938 (61.7)	Producing ≤6 and ≥2 articles	n=6.6	n=6.6	178
Last	409	66.6%	409	1347 (100)	Producing 1 article	n^2=15.1	n^2=43.4	1172
Total	614	100.0%	1347					1377

Figure 2. Distribution of number of articles per journal (solid line) and cumulated percentage of articles (dotted line).

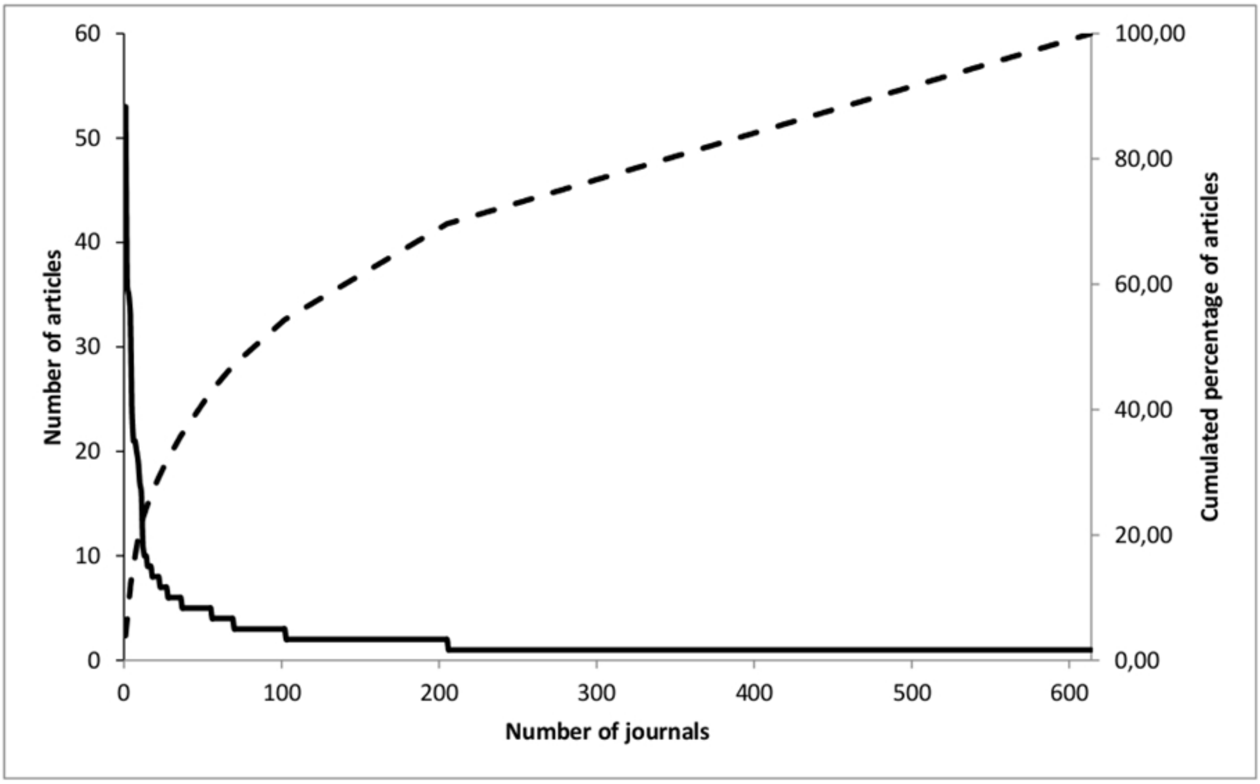


Table 2. Major Web 2.0 publishing journals (journals publishing more than six articles).

Journal	Articles, n=1347 n (%)	Impact factor	MeSH terms[b]
Studies in Health Technology and Informatics[a]	53 (3.93)	N/A	Biomedical Technology; Medical Informatics
Journal of Medical Internet Research[a]	36 (2.67)	3.768	Information Services; Internet; Medical Informatics; Research
Nucleic Acids Research[a]	35 (2.60)	8.278	Nucleic Acids
Cyberpsychology, Behavior and Social Networking[a]	33 (2.45)	N/A	Behavior; Computer Communication Networks/utilization; Multimedia/utilization; Psychology, Social; User-Computer Interface
AMIA. Annual Symposium proceedings / AMIA Symposium. AMIA Symposium[a]	24 (1.78)	N/A	Medical Informatics Applications; Medical Informatics Computing
BMC Bioinformatics[a]	21 (1.56)	3.024	Computational Biology
Medical Reference Services Quarterly[a]	21 (1.56)	N/A	Information Services; Information Systems; Libraries, Medical; Library Services
Medical Teacher[a]	20 (1.48)	1.824	Education, Medical
Nurse Educator[a]	19 (1.41)	0.562	Education, Nursing
PLoS One[a]	17 (1.26)	3.73	Medicine; Science
Bioinformatics (Oxford, England)[a]	16 (1.19)	5.323	Computational Biology; Genome
Health Information and Libraries Journal[a]	11 (0.82)	N/A	Libraries, Medical; Medical Informatics
Genome Biology[a]	10 (0.74)	10.288	Biology; Genetics; Genome
Journal of Medical Systems[a]	10 (0.74)	1.783	Computers; Delivery of Health Care; Information Systems
BMJ (Clinical research ed.)[a]	9 (0.67)	17.215	Medicine
Journal of Digital Imaging[a]	9 (0.67)	1.1	Computer Systems ; Radiographic Image Enhancement; Radiology Information Systems
Journal of Health Communication[a]	9 (0.67)	N/A	Communication; Health Education; Health Promotion; Health Services; Health
Cyberpsychology & Behavior: the impact of the Internet, multimedia and virtual reality on behavior and society[a]	8 (0.59)	N/A	Behavior; Computer Communication Networks/utilization; Multimedia/utilization; Psychology, Social; User-Computer Interface
Health Communication[a]	8 (0.59)	N/A	Communication; Health
Nature[a]	8 (0.59)	38.597	Science
The Journal of Medical Practice Management : MPM[a]	8 (0.59)	N/A	Practice Management, Medical
Vaccine[a]	8 (0.59)	3.492	Vaccines
American Journal of Pharmaceutical Education[a]	7 (0.52)	N/A	Education; Pharmacy
Annual International Conference of the IEEE Engineering in Medicine and Biology Society[a]	7 (0.52)	N/A	Biomedical Engineering
Journal of Dental Education[a]	7 (0.52)	0.989	Education, Dental
Journal of the Medical Library Association : JMLA[a]	7 (0.52)	N/A	Information Services; Libraries, Medical; Library Science
Medical Education[a]	7 (0.52)	3.546	Education, Medical
Caring: National Association for Home Care magazine	6 (0.45)	N/A	Health Services for the Aged; Home Care Services; Long-Term Care
Database: the journal of biological databases and curation	6 (0.45)	4.2	Computational Biology

Journal	Articles, n=1347 n (%)	Impact factor	MeSH terms[b]
Journal of the American Medical Informatics Association : JAMIA	6 (0.45)	3.571	Medical Informatics Applications; Medical Informatics
Nursing education perspectives	6 (0.45)	N/A	Education, Nursing; Nursing
PLoS computational biology	6 (0.45)	4.867	Computational Biology
Science (New York, N.Y.)	6 (0.45)	31.027	Science
The Journal of Adolescent Health: Official Publication of the Society for Adolescent Medicine	6 (0.45)	2.966	Adolescent Medicine
The Journal of Nursing Education	6 (0.45)	1.133	Education, Nursing
Tobacco Control	6 (0.45)	4.111	Smoking/prevention & control; Tobacco Use; Disorder/prevention & control; Tobacco

[a]Core journals according to Bradford's law of scattering.

[b]MeSH terms used in the catalog of the National Library of Medicine to describe the journal.

Language of Publication

A total of 1355 declared languages were retrieved among the 1347 articles. This disparity could be explained by the fact that some articles have two languages declared in the language field in PubMed. The most commonly used language was English (1301/1355; 96.01%), followed by French (17/1355; 1.25%); Spanish (12/1355; 0.89%); German (8/1355; 0.59%); Italian (4/1355; 0.30%); Dutch (3/1355; 0.22%); Japanese, Portuguese (2/1355; 0.15%); and Danish, Greek, Hungarian, Norwegian, Polish, and Swedish (1/1355; 0.07%). The percentage of publications in English for the whole PubMed database was 90.84% for this given period (2002-2011).

Geographical Repartition of Authors (Country Contributions)

For 395 of the 1347 articles (29.32%), it was impossible to identify the contributing country because the author claimed no affiliation and the articles failed to name the country of publication. Therefore, only 952 of the articles studied could be linked to countries. Table 3 shows the number of papers published per country.

The United States was by far the predominant country for authors, with 514 articles (514/952; 54.0%). The second most productive country was the United Kingdom with 87 articles (87/952; 9.1%). Authors from Europe produced 264 articles (264/952; 27.7 %).

Table 3. Number and percentage of articles published per country relative to the affiliation of authors (n=952).

Country	Articles, n (%)
United States	514 (54.0)
United Kingdom	87 (9.1)
Australia	44 (4.6)
Canada	41 (4.3)
China	40 (4.2)
Germany	34 (3.6)
Spain	26 (2.7)
Netherlands	21 (2.2)
France	14 (1.5)
Italy	14 (1.5)
Greece	11 (1.2)
Japan	11 (1.2)
New Zealand	10 (1.1)
Switzerland	10 (1.1)
India	9 (0.9)
Israel	9 (0.9)
Norway	8 (0.8)
Sweden	8 (0.8)
Portugal	6 (0.6)
Belgium	4 (0.4)
Ireland	4 (0.4)
Austria	3 (0.3)
Brazil	3 (0.3)
Bulgaria	3 (0.3)
Egypt	3 (0.3)
Romania	3 (0.3)
Turkey	3 (0.3)
Luxembourg	2 (0.2)
South Africa	2 (0.2)
Argentina	1 (0.1)
Czech Republic	1 (0.1)
Poland	1 (0.1)
Singapore	1 (0.1)
Slovakia	1 (0.1)

Number of Papers Per Author

In total, 4209 authors were found for the 1347 articles retained, corresponding to 3762 different authors. The great majority of authors (91.54%; 3444/3762) wrote only one article, 6.51% (245/3762) wrote two articles, whereas 73 (1.94%; 73/3762) wrote three or more. The maximum number of articles written by one author was 14.

Word Frequency Analysis

A total of 274 words in the field of Web 2.0 were found after manual sorting of the 15,878 words belonging to title and abstract fields. Similar words differing by singular/plural, upper/lower case were aggregated and 99 words finally obtained. As shown in Tables 4 and 5, word frequency analysis reveals that the ten most frequent words or expressions are “blog” followed by “wiki”, “Web 2.0”,”social media”, “Facebook”, "social networks", "blogger", "cloud computing", "Twitter", and "blogging".

In the general category, "Web 2.0" was the most common expression followed by e-health, Health 2.0, and Medicine 2.0. "Blog" was the predominant category of any Web 2.0 application encountered in the biomedical literature, followed by social networks and wiki (1279, 1199, and 803 occurrences, respectively). Micro-blogging, cloud computing, social bookmarking/document sharing, and syndication were much less represented with 332, 260, 183, and 175 occurrences, respectively.

Table 4. Word frequency for general, blog, social network, and wiki categories.

General		Blog		Social network		Wiki	
Word	n	Word	n	Word	n	Word	n
Web 2.0	542	Blog	800	social media	472	Wiki	536
e-health	71	Blogger	259	Facebook	336	Wikipedia	108
Health 2.0	39	Blogging	181	Social network	327	Crowdsourcing	21
Medicine 2.0	36	Blogosphere	30	MySpace	29	MediaWiki	18
Science 2.0	8	Nonbloggers, Blogroll	2	Second life	21	SubtiWiki	17
e-Research	3	Medbloggers, blogspot, Bloglines, blogorrhea, blogsearch	1	LinkedIn	9	WikiPathways	10
O'Reilly	2			PatientsLikeMe	5	myExperiment	9
eScience	1					ArrayWiki	8
						EcoliWiki, SNPedia	7
						Pathowiki, PDBWiki	6
						Channelpedia, UMMedWiki	5
						WikiGenes, WikiPharma, Bowiki, TWiki, Proteopedia,	4
						Casepedia, SEQwiki, Gene_Wiki, WikiBuild	3
						WikiProteins, OperonWiki, meta-wiki, Open-Toxipedia, CHDWiki, Wikisource, Wikibooks, WikiOpener, RAASWiki	2
						Genewikiplus, WikiMedia, wikispaces, Clin-fowiki, wikiprofessional, OpenWetWare, gowiki, sbwWiki, WikiTrust, Wikipedians, Medi-wiki	1
Total	702	Total	1279	Total	1199	Total	803

Table 5. Word frequency for microblogging, cloud computing, social bookmarking/document sharing, and syndication categories.

Micro blogging		Cloud computing		Social Bookmarking/ document sharing		Syndication	
Word	n	Word	n	Word	n	Word	n
Twitter	205	cloud computing	209	YouTube	89	podcast	69
Tweet	73	Amazon	33	Tag	31	RSS	56
micro-blogging	31	CloudLCA	6	social bookmarking	29	syndication	37
Weibo	12	CloudMan	3	Tagging	13	podcasting	11
Tweeting	6	SurveyMonkey, Netvibes, CloudBi-oLinux, GeoCommons	2	Folksonomy	11	uBioRSS	2
iScience	3	CloudBurst	1	video-sharing	4		
micro-blog	2			Delicious	3		
				Digg, CiteULike, Slideshare	1		
Total	332	Total	260	Total	183	Total	175

Discussion

Principal Findings

The appearance of literature relating to Web 2.0 in the biomedical field is recent, and correlates with the year 2005, when Web 2.0 became popular [1]. Some Web 2.0 applications existed before this date, which is why some articles were identified earlier. The scientific production of Web 2.0 really started in 2006 and has been growing rapidly ever since. The comparison of average annual growth rate for Web 2.0 related articles and for the whole PubMed database (106.30% and 6.27%, respectively) has confirmed that the topic continues to be of much interest to the biomedical community.

Using Bradford's law of scattering, the theoretical ratio of number of journals (43.4) and theoretical number of journals in the last third (1172) were higher than the values obtained experimentally (15.1 and 409, respectively). Thus, articles related to Web 2.0 are published in a lesser number of journals (n=614) than the expected Bradford theoretical value (n=1377). This can be explained by the innovative nature of the subject studied, which has not yet been taken into account by a great number of journals.

In the list of the 38 journals that published more than six articles, including core journals according to Bradford's law (Table 2), widely disseminated journals with high impact factors (IF) are present: three are in the 100 journals that have the highest IF (Nature, Science, BMJ), and one is in the top 10 (Nature, IF=38.597). Six journals out of 38 (16%) have an IF greater than 5, whereas, in the complete Journal Citation Reports, the percentage with an IF higher than 5 is 6.2%, indicating that journals with significant scientific influence are interested in Web 2.0. Only one of the 38 journals that published more than six articles, the Journal of Medical Internet Research, specializes in Internet studies. It should be noted that many journals with educational objectives are in this list, because Web 2.0 tools and techniques are new and their comprehension and utilization require a learning period.

English was by far the most predominant language of the articles included in the study, and the percentage of articles in English was higher compared to the entire PubMed database (96.01% and 90.84%, respectively). This can be explained by the fact that English is the official language for scientific publications in most countries. As mentioned elsewhere [24,25], PubMed is a US database, so it may have introduced a bias because most of the journals indexed are written in English, which could accentuate its predominance. These observations match those of other studies done with bibliometrics in fields where information is predominantly found in English.

The United States was by far the most productive country. Europe came second globally, whereas Africa and South America were very poorly represented.

Distribution of number of articles per author shows that the great majority of authors (91.54%; 3444/3762) wrote only one article, whereas 73 (1.94%; 73/3762) wrote three or more. Thus, the core population of researchers working on Web 2.0 in the biomedical field can be estimated to approximately 75.

Considering generalist terms or expressions, the word frequency analysis reveals "Web 2.0" as the most common term, followed by "e-health", "Health 2.0", and "Medicine 2.0", which are the expressions most commonly used to describe Web 2.0 technologies applied in this field [8].

The most represented category of the eight was blog (1279 occurrences). This can be explained by the fact that blogs are among the oldest Web 2.0 applications and the facility of their implementation has established their popularity. Quite logically, in the second category, "social network", the well-known Facebook was by far the most represented. Among wikis, Wikipedia was the most represented term. The high number of terms in this category is due to the many applications based on wiki platforms developed by researchers, and most of the articles related to these terms are actually presentations of these applications. The most cited micro-blogging application was, as expected, Twitter, confirming its high popularity. Cloud computing applications, currently on the rise, are also well represented, even though access to them is fairly recent compared to that of blogs or wikis. Amazon, best known for its online shopping website, is cited because it also offers solutions for the development of cloud computing applications. The category social bookmarking / document sharing was predominantly represented by YouTube. Unexpectedly, social bookmarking sites specially developed for the scientific field were scarce (eg, Citeulike), or simply not present (eg, Connotea or Bibsonomy). The same can be said of other categories in which the most represented terms were related to popular applications (Facebook, YouTube, Wikipedia, and Twitter, respectively the first, third, sixth, and tenth most consulted sites in the world according to [26]). Of note, apart from wikis, applications specifically developed for science, biology, or medicine were rare (eg, PatientsLikeMe) or not represented in every category (eg, researchblogging.org for blogs, Researchgate and Academia for social networks).

Limitations

One should be aware that this study presents some limits: for even if PubMed is widely used for bibliometric analysis, it does not contain all biomedical journals [24], and some relevant articles may have been omitted. Furthermore, the methodology for identifying the country of authors (PubMed) indicates only one country per article and fails to identify transnational research. Moreover, some articles (395/1347; 29.32%) did not mention any country of affiliation for authors. Therefore, the geographical repartition of the latter might be underestimated in some locations [27]. Furthermore, some Web 2.0 applications, specifically developed for biology or medicine, may not have been retrieved by the search because they were only named and not described as Web 2.0 applications in articles.

Conclusions

This paper presents an exploration of the geographical distribution and temporal trends of the biomedical literature related to Web 2.0 found in PubMed, together with an analysis of related words and expressions. The study indicates the ongoing expansion of a field currently dominated by the United States. All categories of Web 2.0 applications abound within the literature, indicating that Web 2.0 has been integrated into the biomedical field. Of note, applications developed specifically for biology and medicine were less represented than their generalist counterparts (eg, Facebook, Twitter). The study of articles published clearly shows a great diversity of journals, including those with significant scientific influence, displaying interest in Web 2.0, and confirms the high level of interest the topic holds for the biomedical community. Therefore, the changes in the informational uses of researchers, initiated by the arrival of the World Wide Web and continued by Web 2.0, seem to be far from over.

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Conflicts of Interest

None declared.

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Abbreviations

IF: impact factor
MeSH: medical subject headings
PHP: hypertext preprocessor language
XML: Extensible Markup Language

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