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Relations between the use of eHealth and the use of general practitioner and somatic specialist visits in patients with type 1 diabetes: A cross-sectional study

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Abstract

Background
The prevalence of diabetes and the use of eHealth are increasing. People with diabetes need frequent monitoring and follow-up of health parameters and eHealth services can be of great value. However, little is known about the association between the use of eHealth and provider-based health care services among people with diabetes.

Objective
The objective of this study was to investigate the use of four different eHealth platforms (apps, search engines, video services, and social media sites) and associations with the use of provider-based health care visits among people diagnosed with type 1 diabetes mellitus (T1DM).

Methods
We used e-mail survey data from 1,250 members of The Norwegian Diabetes Association (aged 18-89 years), conducted in 2018. Eligible for analyses were the 523 respondents with T1DM. Using descriptive statistics, we estimated the use of eHealth and the use of general practitioners (GPs) and somatic specialist outpatient services. By logistic regressions, we studied the associations between the use of these provider-based health services and the use of eHealth, adjusted for gender, age, education, and self-rated health.

Results
Of the sample of 523 people with T1DM, 90.7% had visited a GP once or more and 61.0% had visited specialist services during the previous year. Internet search engines (like Google) were used sometimes or often by 84.0%, apps by 55.5%, social media (like Facebook) by 45.2%, and video services (like YouTube) by 23.3%. Participants aged 18-39 years used all forms of eHealth more than people aged 40 years and over, with the exception of social media. The use of search engines was positively associated with the use of somatic specialist services (odds ratio [OR] 2.56, confidence interval [CI] 1.40-4.68). GP visits were not associated with any kind of eHealth use.

Conclusions
eHealth services are now widely used for health support and health information by people with type 1 diabetes, primarily in the form of search engines, but often in the form of apps and social media as well. We found a positive association between the use of search engines and specialist visits, and that people with T1DM are frequent users of eHealth, GPs, and specialist services. We found no evidence that eHealth reduces the use of provider-based health care, and these services seem to be additional rather than alternative. Future research should focus on how health care services can meet and adapt to the high prevalence of eHealth use. Our results also indicate that many patients with T1DM do not visit specialist clinics once a year as recommended. This raises questions about collaboration in health care services, and needs to be followed up in future research.

Keywords
Use of eHealth, Internet, health care utilization, cross-sectional study, diabetes mellitus type 1, Norway
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Introduction

Internet-based health information, sensors, apps and other solutions for self-management, as well as new treatment strategies have developed rapidly in recent years, becoming an important support for both patients and health services. Of particular interest in this regard are patients with chronic disease, such as diabetes, who are in need of frequent monitoring and follow-up of health parameters.

Increasing prevalence of diabetes mellitus

The prevalence of diabetes is increasing worldwide. Estimates of 415 million cases in 2015 (age group 20-79 years) are expected to rise to 642 million in 2040 [1]. Global prevalence in adults is estimated at 8.8% [1] and the Norwegian prevalence at 4.7% [2]. Around 245,000 persons are diagnosed with diabetes in Norway, of whom around 28,000 have type 1 diabetes (T1DM) [2]. Costs attributable to diabetes represent around 1.4% of the total Norwegian expenditure on health care [3]. Diabetes is a considerable burden on patients in terms of morbidity and mortality [4]. Most patients do not reach the combined national treatment targets for prevention of complications [5-7].

Increasing use of eHealth services

World Health Organization states that “eHealth is the use of information and communication technologies (ICT) for health” [8]. The use of eHealth has increased over the past decades. Back in 2005, 44% of the general population of seven European counties reported using the Internet for health purposes [9, 10], increasing to 52.2% by 2007 [11]. In Poland, which is consistent with European trends, 66.7% used the Internet for health purposes in 2012 [12]. Around 75-80% of Internet users in USA and Europe conduct health-related searches [9, 13]. Most Norwegian households (97%) had Internet access in 2015 [9-11, 14], and 78% of the population aged 15 years and older have reported using the Internet for health purposes [15]. In the Czech Republic, more than 25% of insulin treated patients visited a professional diabetes Internet portal in the period between 2009 and 2013 [16]. However, eHealth use among people with T1DM in Norway has yet to be explored.

Unclear relations between the use of eHealth and provider-based health services

Andreassen et al found that the use of eHealth in a general population was positively associated with general practitioner (GP) visits (yes/no) [10], whereas others have reported no or inverse associations with the frequency of regular provider visits [17, 18]. A German study found that heavy users of health services were 73% more likely to seek health information on the Internet compared to non-users [12]. Research on the associations between the use of eHealth and provider-based health care is scarce, both in general populations and for populations with specific diseases [19, 20].

Norwegian health care services

The Norwegian health care system is based on universal insurance. Primary health care is run by the municipalities. All residents are provided a regular GP according to the patient list system. Specialist outpatient services are operated by regional and local health enterprises
owned by the national government, consisting of public and private somatic and psychiatric specialist services. Access to specialist care is usually achieved by referral from the regular GP (the gatekeeper role). However, persons with T1DM are recommended to make at least one annual visit to specialist health services [21] and are most often invited directly for annual checks. GP and specialist visits for adults have a small copayment, with a total maximum limit of NOK 2,258 (around USD 280) within a year (2018).

Planning for future eHealth and provider-based health care services
The use of eHealth is an area of continuous and rapid development, which varies between regions, countries, diagnostic groups, health care services, and health care systems. Hence, research from different settings is important to achieve an overall epidemiological view. A comprehensive understanding of the influence of eHealth on health care utilization in patients with T1DM is thus important for patients, health care providers, administrators, policy makers, and society, in order to enable evidence-based planning for future eHealth and provider-based health care services.

Aim
The aim of this study was to investigate which eHealth services are used among people with T1DM and whether the use of eHealth is associated with the use of primary and specialist health care services. Specifically, we tested whether the use of apps, search engines (like Google), video services (like YouTube), and social media (like Facebook) were associated with the use of GPs and somatic outpatient specialist services.

Methods
Data
For this cross-sectional study we used e-mail survey data obtained in January and February 2018 from members of The Norwegian Diabetes Association. At 31.12.2017, the organization had 33,908 members, 53% women and 47% men. Around 30% of the members have T1DM [22]. The Norwegian Centre for Research Data (NSD) Web Survey distributed the invitations to a randomly selected sample of 5,971 individuals (about 18% of all members).

Initially, as described in our protocol paper [23], we planned to use data from the seventh Tromsø Study, conducted in 2015/2016. However, the Tromsø Study was not able to give us access, due to an agreement with another researcher on exclusive rights to decide about the collected eHealth data for 3 years. Consequently, we had to change our data collection plans. We developed a tailored questionnaire based on the specific objectives of our study [23], using relevant questions from other published surveys on health care utilization and health information seeking [24, 25].

Information about the study purpose and what participation would entail was distributed together with the invitation. The questionnaire (Appendix 1) included questions about demographic and socio-economic characteristics, health status including specific questions about duration, severity and treatment, and use of and experiences with eHealth and health care services. Before data collection, the questionnaire was reviewed and tested several times by two persons diagnosed with diabetes, and by experts from our research group (EÅ and AHH). Non-respondents were given one reminder, submitted by e-mail 15 days after the first request.
Participants
It was not possible for the same respondent to fill in the questionnaire more than once. Starting from 1,250 participants, we first excluded those who did not suffer from diabetes themselves (n=66). This group consisted of 61 family members, 4 health personnel (2 overlapping), and 3 others. We also excluded participants who failed to respond to most of the questions (n=5) and those who did not give information about gender (n=93). Finally, since we had decided to investigate T1DM in this part of the study, participants with T2DM and other diabetes types were excluded. The sample finally consisted of 523 respondents (Figure 1).

Figure 1. Flow chart of study population

Variables
The dependent variables were use of GPs and outpatient specialist services during the previous 12 months. Specialist services use refers to any somatic specialist clinic visit, regardless of clinical issue (not only endocrinologists/diabetologists). For GP services, two dichotomous outcome variables were applied, one for use or no use, and one for less frequent use (0-2 visits) or more frequent use (3 visits or more). The distinction between more and less frequent use was the 50th percentile. For outpatient specialist visits the 50th percentile was set at 1, making a frequency variable redundant.

Respondents were asked about their use of eHealth in the same period. eHealth was subdivided into apps for smartphone or tablet computer, search engines (like Google), social media (like Facebook), and video services (like YouTube). eHealth variables were dichotomized by merging the original four answering options into “never or once” and “sometimes or often”.

The use of eHealth (apps, search engines, social media, and video services) were the key independent variables. Adjustment independent variables were gender, age, education, and self-rated health. We grouped age in 20-year intervals, but used it as a continuous variable in
the regression models. The four education categories were labeled low (primary/part of secondary school), middle (completed secondary school), high (college/university < 4 years), and highest (college/university 4 years or more). Response options for self-rated health were excellent, good, fair, bad, and very bad. The bad and very bad categories were merged due to low numbers in the very bad category (4 respondents).

**Analyses**

Data were analyzed by means of descriptive statistics and logistic regressions. Correlations were tested with Spearman’s correlation coefficients. We constructed one multivariable regression model for each of the dependent variables. The independent variables (apps, search engines, social media, video services, gender, age, education, and self-rated health) were introduced collectively into the models.

Due to a relatively low response rate, we compared respondents who did not respond initially but eventually consented with early respondents, assuming that late respondents were more similar to non-respondents [26]. This was done by descriptive statistics (stratification), and by subsequently introducing the response time variable into the regression models.

We used 95% confidence intervals (CI) throughout the study. All analyses were accomplished using Stata, version 14.2.

**Ethics**

This project has been presented to the Regional Committee for Medical and Health Research Ethics (REK), which found that an application was not required according to the Norwegian Health Research Act (2015/1779/REK nord). The study has been approved by the Data Protection Officer (Personvernombudet) at the University Hospital of North-Norway (ref 2017/6579). The data bureau NSD received no other information about the participants than the e-mail addresses.

**Results**

In total, 1,250 persons aged 18-89 years participated, constituting a minimum response rate of 20.9% (Figure 1). However, we experienced more than 400 bounce backs from servers unable to deliver the invitation. Consequently, the real response rate is assumed higher. Eligible for analysis in our study were the 523 persons who reported having T1DM (Fig 1).

**Sample characteristics**

Mean age was 47.0 years, 48.9 years for men and 45.3 years for women. Median age was 48 years. Mean disease duration was 23.2 years (median 22 years). Most participants (75.7%) had suffered from diabetes for 10 years or more. Women, persons aged 40-59 years, married/cohabitants, full-time or part-time employed persons, persons with high education, high household income, good self-rated health, and good self-rated regulation of diabetes made up the largest groups. Among the late respondents (those who responded after the reminder), older people represented a larger proportion (Table 1).
<table>
<thead>
<tr>
<th>Table 1. Sample characteristics (%)</th>
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<tbody>
<tr>
<td></td>
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<tr>
<td><strong>Gender</strong></td>
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<td></td>
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<tr>
<td>Female</td>
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<tr>
<td>Male</td>
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<tr>
<td><strong>Age</strong></td>
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<tr>
<td>18-39</td>
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<td>40-59</td>
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<tr>
<td>60+</td>
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<tr>
<td><strong>Marital status</strong></td>
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<tr>
<td>Single</td>
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<tr>
<td>Married/cohabitant</td>
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<tr>
<td><strong>Main daily activity</strong></td>
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<td>Workinga</td>
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<tr>
<td>Pensioner old age</td>
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<tr>
<td>Pensioner disability</td>
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<tr>
<td>Pupil/student</td>
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<tr>
<td>Other</td>
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<tr>
<td><strong>Educationb</strong></td>
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<tr>
<td>Low</td>
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<tr>
<td>Middle</td>
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<td>High</td>
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<td>Highest</td>
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<tr>
<td><strong>Household incomec</strong></td>
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<tr>
<td>Low</td>
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<tr>
<td>Middle</td>
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<tr>
<td>High</td>
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<tr>
<td><strong>Duration of diabetes</strong></td>
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<tr>
<td>&lt; 10 years</td>
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<tr>
<td>10-19 years</td>
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<tr>
<td>20-29 years</td>
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<tr>
<td>30 years and over</td>
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<tr>
<td><strong>Self-rated regulation of diabetes</strong></td>
</tr>
<tr>
<td>Excellent</td>
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<tr>
<td>Good</td>
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<tr>
<td>Fair</td>
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<td>Bad/very bad</td>
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<tr>
<td><strong>Self-rated health</strong></td>
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<tr>
<td>Excellent</td>
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<tr>
<td>Good</td>
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<tr>
<td>Fair</td>
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<td>Bad/very bad</td>
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</tbody>
</table>

a: Full-time or part-time
b: Low (primary/part of secondary school), Middle (completed secondary school), High (college/university < 4 years), Highest (college/university 4 years or more)
c: Low (NOK <350,000), Middle (NOK 351,000-750,000), High (NOK >750,000)
The use of eHealth and provider-based health care services

During the previous year, 90.7% visited a GP once or more and 61.0% visited somatic outpatient services (Table 2). Overall, 87.0% (447/514) used eHealth in one or more forms. Search engines were used sometimes or often by 84.0%, apps by 55.5% social media by 45.2% and video services by 23.3% (Table 2). People aged 40 years and over used all health care services more and all forms of eHealth less than younger people, with the exception of social media (Table 2).

Table 2. Proportion using provider-based health care services and four kinds of eHealth during the previous 12 months

<table>
<thead>
<tr>
<th></th>
<th>Total T1DM sample n/N (%)</th>
<th>Early respondents n/N (%)</th>
<th>Late respondents n/N (%)</th>
<th>18-39 years n/N (%)</th>
<th>40-59 years n/N (%)</th>
<th>60 years and over n/N (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Use of health care services once or more</strong></td>
<td></td>
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</tr>
<tr>
<td>GP</td>
<td>441/486 (90.7)</td>
<td>293/324 (90.4)</td>
<td>148/162 (91.2)</td>
<td>132/157 (84.1)</td>
<td>198/211 (93.8)</td>
<td>111/118 (94.1)</td>
</tr>
<tr>
<td>Somatic outpatient specialist</td>
<td>289/474 (61.0)</td>
<td>182/313 (58.2)</td>
<td>107/161 (66.5)</td>
<td>82/154 (53.3)</td>
<td>140/208 (67.3)</td>
<td>67/112 (59.8)</td>
</tr>
<tr>
<td><strong>Use of eHealth sometimes or often</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Apps</td>
<td>285/514 (55.5)</td>
<td>194/337 (57.6)</td>
<td>91/177 (51.4)</td>
<td>108/173 (62.4)</td>
<td>121/219 (55.3)</td>
<td>56/122 (45.9)</td>
</tr>
<tr>
<td>Search engines</td>
<td>431/513 (84.0)</td>
<td>293/337 (86.9)</td>
<td>138/176 (78.4)</td>
<td>159/173 (91.9)</td>
<td>184/218 (84.4)</td>
<td>88/122 (72.1)</td>
</tr>
<tr>
<td>Social media</td>
<td>232/513 (45.2)</td>
<td>154/336 (45.8)</td>
<td>78/177 (44.1)</td>
<td>78/173 (45.1)</td>
<td>108/218 (49.5)</td>
<td>46/122 (37.7)</td>
</tr>
<tr>
<td>Video services</td>
<td>118/506 (23.3)</td>
<td>80/332 (24.1)</td>
<td>38/174 (21.8)</td>
<td>45/170 (26.5)</td>
<td>51/217 (23.5)</td>
<td>22/119 (18.5)</td>
</tr>
</tbody>
</table>

Relations between the use of provider-based health care services and eHealth

People in poorer self-rated health were more likely to use GPs (odds ratio [OR] 2.57, confidence interval [CI] 1.53-4.33) and somatic outpatient services (OR 1.35, CI 1.06-1.71). Likewise, higher age increased the probability of visiting GPs (OR 1.05, CI 1.02-1.08) and somatic outpatient services (OR 1.02, CI 1.00-1.03) (Table 3).

GP visits (yes/no) were not associated with any kind of eHealth use. Findings were similar regarding the frequency of GP visits, as higher age and poorer self-rated health were the only independent variables significantly associated with increased use (OR 1.03, CI 1.01-1.04 and OR 1.99, CI 1.55-2.57, respectively). The use of search engines was positively associated with the use of somatic outpatient services (OR 2.56, CI 1.40-4.68) (Table 3). Gender, education, and the use of social media or video services were not associated with the use of health care services (Table 3).
Table 3. Probability of using GPs and somatic outpatient services once or more during the previous year in a population with diabetes type 1 (multivariable logistic regressions)

<table>
<thead>
<tr>
<th></th>
<th>GPs (n=474) OR for trend (95% CI)</th>
<th>Somatic outpatient services (n=468) OR for trend (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apps&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.23 (0.60-2.54)</td>
<td>0.64 (0.41-1.01)</td>
</tr>
<tr>
<td>Search engines&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.94 (0.34-2.57)</td>
<td>2.56 (1.40-4.68)</td>
</tr>
<tr>
<td>Social media&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.42 (0.64-3.17)</td>
<td>1.22 (0.78-1.92)</td>
</tr>
<tr>
<td>Video services&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.85 (0.69-4.98)</td>
<td>1.04 (0.63-1.70)</td>
</tr>
<tr>
<td>Gender&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.59 (0.29-1.18)</td>
<td>0.99 (0.66-1.48)</td>
</tr>
<tr>
<td>Age in years</td>
<td>1.05 (1.02-1.08)</td>
<td>1.02 (1.00-1.03)</td>
</tr>
<tr>
<td>Education&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.87 (0.60-1.26)</td>
<td>1.23 (0.99-1.51)</td>
</tr>
<tr>
<td>Self-rated health&lt;sup&gt;d&lt;/sup&gt;</td>
<td>2.57 (1.53-4.33)</td>
<td>1.35 (1.06-1.71)</td>
</tr>
</tbody>
</table>

Statistically significant findings are marked in italics.

<sup>a</sup>: Apps/search engines/social media/video services in two groups: 1=never or once, 2=sometimes or often.
<sup>b</sup>: Gender: 1=women, 2=men.
<sup>c</sup>: Education: 1=Low (primary/part of secondary school), 2=Middle (high school), 3=High (college/university < 4 years), 4=Highest (college/university 4 years or more).
<sup>d</sup>: Self-rated health 1=Excellent, 2=Good, 3=Fair, 4=Bad/very bad.

All findings persisted after introduction of the response time variable into the regression models, except that the probability of using somatic outpatient services increased significantly among the late respondents (OR 1.66, CI 1.08-2.55).

There were no strong correlations (defined as rho >0.5) between the independent variables in any of the models.

**Discussion**

**Principal findings**

We found that 90.7% of study participants visited a GP once or more during the previous year and 61.0% visited somatic outpatient services. Search engines were used sometimes or often by 84.0%, apps by 55.5% social media by 45.2% and video services by 23.3%. Participants aged 18-39 years used the investigated forms of eHealth more than people aged 40 years and over, with the exception of social media. GP visits were not associated with the use of eHealth, whereas visits to specialist services were positively associated with the use of search engines. Poorer self-rated health and higher age were associated with increased use of GPs and specialist services, whereas gender, education, social media use, and video services use were not.

**Low specialist visit rate**
We were surprised that only 61% reported one or more visits to any somatic specialist service during the previous 12 months. This is a higher rate than reported for the general population [27], but still remarkably low since at least one annual check-up visit is recommended for people diagnosed with T1DM [21]. In Salten, Norway, around 80% of insulin treated patients reported visits to specialist services regarding their diabetes during 2014 (unpublished data from the Rosa4 Study, communicated by TCL). We have not found other studies reporting specialist check-up rates for patients with T1DM in Norway; however, it has been suggested that many older patients are monitored by their GP [7]. This notion is only partly backed by our results, since low rates of specialist visits apply to all age groups, and in particular to younger ages (18-39 years) (Table 2). On the other hand, a GP visit rate of 90.7% is high compared to around 80% in the general population [25, 27]. Patients with T1DM might see their GP for a variety of health problems that are connected, directly or indirectly, to their diabetes. A few GPs have specialized in diabetes care, - and may partly provide a substitute for specialist clinic check-up. This might explain some of the low specialist visit rate, but it is unlikely to explain all of it. The notion that people with T1DM are followed up by annual check-ups in specialist services thus needs to be questioned, or at least nuanced. It may be problematic if the GP and the specialist both believe that the other is performing the check-up of their patients, with the risk of dropouts. Our finding raises questions about the collaboration between GPs, specialist health services, and patients, and needs to be followed up in further research.

**Extensive use of eHealth**

Our finding that people with T1DM are heavy users of all four forms of eHealth is not surprising. The different kinds of eHealth were used from around twice (search engines) to five or six times (apps, video services and social media) more than reported for the general population in the Tromsø Study [25]. However, it should be noted that our data were collected two to three years later than the Tromsø Study. Considering the rapid development in this field, some of the differences might be due to changing of trends over time. Nevertheless, reports are quite consistent that people with chronic conditions or poorer self-rated health are more likely to use eHealth than the general population [28-32]. This conforms with the illness behaviour model [33], indicating that people in poor health are more likely to seek disease-related information online, where an obvious prerequisite is online access [34]. Concerns about one’s own disease or poor health will naturally lead to online demand for relevant information.

This extensive use may reinforce the notion that eHealth and provider-based health care are additional rather than alternative services at present, possibly interacting in a reciprocal way [32, 35], and that this applies at least as much to people with T1DM as to the general population.

**The age divide**

This study confirms that younger people use the Internet for health purposes more than older people, particularly apps and search engines. Previous research is consistent regarding this age divide, for general populations, elderly populations, and populations with chronic disease [10, 11, 15, 17, 32, 36-40]. Findings by Tarver et al may indicate that age differences among Internet users decreased in the period 2003-2013, although this finding was not statistically significant [40]. This possible trend may amplify when cohorts exposed to digital technology from childhood get older, and the present inverse association between age and eHealth use might not be sustained to the same extent in the future. Elderly people are a rapidly growing age group in Europe, and a fast-growing group of eHealth users [12, 41].
Positive association between specialist visits and the use of search engines
GP visits were not associated with any kind of eHealth use, whereas specialist visits were positively associated with the use of search engines. Back in 2008, Lee suggested that Internet use for health information increased contact with health professionals [35]. In line with this, two Asian studies recently found that Internet use was significantly associated with more outpatient clinic visits [28, 42]. Medlock’s study of elderly people in the Netherlands, however, reported that use of health professionals was not associated with Internet use [24]. None of these studies can be directly compared to the current study, since study methodology, health care systems, and cultures differ substantially, and they have not been performed in disease specific populations. The specific finding of an association between specialist visits and the use of search engines among people with T1DM may point to a need for additional information concerning specialist visits, which may be greater than the need connected to GP visits. We know that eHealth might be used before the visit to seek information or to decide about the need to see a doctor, and after the visit for additional information [30, 32, 43]. The GP-patient relationship may have a longer duration, and GP visits may be more frequent than specialist visits. Thus, a closer relationship with continuity combined with room for questions and discussions may develop [44]. In Norwegian specialist care, the patient will not necessarily see the same physician from one visit to the next, and the Internet may be of great value as a source of supplemental information.

Gender, education, self-rated health and late respondents
The use of eHealth was not associated with gender or education, which is also reported from other populations [40, 45]. However, others’ findings are not consistent in this regard [17, 30, 32, 33, 39], most likely because studies have been conducted at different times in different countries and cultures.

People in poorer self-rated health used the surveyed provider-based health services significantly more than people in better health. This adds to solid documentation in previous research, both for disease-specific and general populations [28, 46].

The increased probability of using somatic outpatient services among the late respondents in our study is most likely due to the higher age in this group, and the consequences related to health care needs. Otherwise, our investigation of early vs late respondents did not alter the results.

Limitations
The main limitation of this study is the low participation rate, one of the indicators of study representativeness [47]. However, response rate must not be confused with response quality [26]. More important is the assessment of the possible influence of non-participation on exposure, outcome or the relation of interest [48]. In our study, older people dominated among the late respondents compared to the early respondents. Assuming that late respondents are more similar to non-respondents, younger individuals may be overrepresented in our study.

The distribution of the questionnaire to people with e-mail addresses excluded those who do not use the Internet or do not have an e-mail address. The distribution of functioning e-mail addresses might have been skewed, for instance towards younger members. However, since 97% of Norwegian households have Internet access, 90% of Norwegians use the Internet every day, and around 91% use e-mail [41], we do not think this has affected our results.
significantly. Nevertheless, some of those invited might not use e-mail regularly, and some may use mobile phones more than computers. In both cases, there might be barriers to filling out a large questionnaire. In Norway, younger people use e-mail less and mobile phones more than middle-aged and older people [41]. In addition, participation in surveys is generally lower among younger people [49]. These factors might contribute to balance a possible overrepresentation of younger people in this study, and consequently add to its generalizability.

It is well known that women, healthier persons, higher socio-economic groups, and middle-aged people are more likely to participate in surveys [48, 49]. This suggests that women, people around 40 to 80 years, people in better health, and higher socio-economic groups might be overrepresented in our study, thus tending to level out a possible skewness in the opposite directions.

Further, we presume that people with interest in eHealth might be overrepresented, as interest in the topic studied has shown to increase responses [50]. If this is the case, our rates of eHealth use might be higher than the true rates. However, this point applies to most other eHealth studies as well.

In questionnaire data there is always a potential for recall bias, particularly regarding minor events and distant past, usually leading to underreporting [51]. In addition, the validity of self-reported data of health care utilization may be questioned, although agreement between self-reported and registered health care use is generally high [52].

The cross-sectional study design implies that no causal relationships can be established. Furthermore, we cannot exclude the possibility of unmeasured confounders of the reported associations.

In sum, we conclude that younger individuals might be overrepresented in this study. It is not possible to judge the magnitude of a possible bias, since different factors might pull the tendency in different directions, or level each other out. The low response rate is in itself not an indication of low representativeness, as non-response bias may be a problem even if response rates are high [53]. Moreover, our results seem reasonable and not contradictory to prior research where such is available. We suggest that bias poses a limited threat to our study’s validity. Nevertheless, generalization must be approached with caution.

Strengths
One strength of this study is the focus on an area that has been scarcely investigated. Another strength is the fact that we were able to design a questionnaire specifically tailored to people with diabetes. This enabled us, for instance, to distinguish between T1DM and T2DM. Further, we were able to recruit participants from all of Norway, not only from Tromsø municipality, as planned in the protocol using data from the Tromsø Study. The present study included individuals from 18 years of age, whereas participants in the Tromsø Study were 40 years and older. Moreover, we were able to analyze data shortly after they were collected, which we consider of great importance in the rapidly developing field of eHealth. Finally, yet importantly, the collection of data in cooperation with the Norwegian Diabetes Association enabled us to develop excellent user participation with a large and important group of health care users.

Future plans
We plan to extend this study by investigating how eHealth use and use of other health care services, like emergency departments and hospitalizations, might be related. Furthermore, we will make efforts to contribute to a deeper understanding of possible causal relationships regarding the use of eHealth and provider-based health care services. In further studies, this will be applied to populations with diabetes type 2, as well as type 1.

Conclusions
We found that the eHealth services are widely used for health information by people with T1DM, primarily in the form of search engines, but often in the form of apps and social media as well. Our study suggests a positive association between the use of search engines and specialist visits, and that people with T1DM are frequent users of eHealth, GPs, and specialist services. We found no evidence that eHealth reduces the use of provider-based health care, suggesting that these services are additional rather than alternative in today’s health care. For future research, it would be interesting to investigate how eHealth services may replace some of today’s face-to-face consultations. Moreover, our results indicate that many patients with T1DM do not visit specialist clinics once a year as recommended. This raises questions about the collaboration between GPs, specialist services, and patients, and needs to be followed up in future research.

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Conflicts of interest
The authors declare that they have no competing interests.

Multimedia Appendix 1
Questionnaire

Authors’ contributions
All authors contributed to the design and conduct of the study. AHH drafted the manuscript. All authors contributed with improvements and critical revisions, and approved the final version for publication.

List of abbreviations
GP: General Practitioner
NSD: The Norwegian Centre for Research Data
REK: Regional Committee for Medical and Health Research Ethics
OR: Odds ratio for trend
CI: Confidence interval
T1DM: Type 1 Diabetes Mellitus
T2DM: Type 2 Diabetes Mellitus
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