*sustainability*

MDPI

*Article*

# Characteristics and Classification of Technology Sector Companies in Digital Health for Diabetes

**Satoru Kikuchi [1], Kota Kadama [2] and Shintaro Sengoku [1,*]**

[1] Department of Innovation Science, School of Environment and Society, Tokyo Institute of Technology, Tokyo 108-0023, Japan; kikuchi.s.aa@m.titech.ac.jp
[2] Graduate School of Technology Management, Ritsumeikan University, Osaka 567-8570, Japan; kkodama@fc.ritsumei.ac.jp
* Correspondence: sengoku@mot.titech.ac.jp; Tel.: +81-(0)3-3454-8907

**Abstract:** In recent years, technological progress in smart devices and artificial intelligence has also led to advancements in digital health. Digital health tools are especially prevalent in diabetes treatment and improving lifestyle. In digital health's innovation ecosystem, new alliance networks are formed not only by medical device companies and pharmaceutical companies but also by information and communications technology (ICT) companies and start-ups. Therefore, while focusing on digital health for diabetes, this study explored the characteristics of companies with high network centralities. Our analysis of the changes in degree, betweenness, and eigenvector centralities of the sample companies from 2011 to 2020 found drastic changes in the company rankings of those with high network centrality during this period. Accordingly, the following eight companies were identified and investigated as the top-ranking technology sector companies: IBM Watson Health, Glooko, DarioHealth, Welldoc, OneDrop, Fitbit, Voluntis, and Noom. Lastly, we characterized these cases into three business models: (i) intermediary model, (ii) substitute model, and (iii) direct-to-consumer model, and we analyzed their customer value.

**Keywords:** digital health; alliance networks; technology sector; diabetes



**Citation:** Kikuchi, S.; Kadama, K.; Sengoku, S. Characteristics and Classification of Technology Sector Companies in Digital Health for Diabetes. *Sustainability* **2021**, *13*, 4839. https://doi.org/10.3390/su13094839

Academic Editor: Antonio Botti

Received: 30 March 2021
Accepted: 23 April 2021
Published: 26 April 2021



## 1. Introduction

### *1.1. Trends in Digital Health and the Treatment of Diabetes*

Since 2015, technological progress in smart devices and artificial intelligence (AI) has led to advancements in the field of digital health. Healthcare has always been affected by new technology as evidenced by telecommunications-led telemedicine in the 1970s and 1980s, internet-enabled e-health in the 1990s, mobile device-enabled mHealth since 2010, and, presently, digital health [1]. According to the Food and Drug Administration (FDA) [2] in the US, the scope of digital health includes categories such as mobile health (mHealth), health information technology (IT), wearable devices, telehealth and telemedicine, and personalized medicine. Digital health is considered a "lean innovation" that is expected to increase cost efficiency. Currently, healthcare in developed countries is expensive and accounts for over 10% of their GDPs; therefore, reducing healthcare costs is a major concern for these countries. In addition, the growing aging population in these countries is expected to increase the number of patients with chronic diseases such as diabetes, which would further increase healthcare costs [3]. In contrast, developing countries severely lack essential medical and healthcare services, and the situation can be aided by innovations in digital health. Hence, digital health offers solutions to both developed and developing countries.

Digital health involves the use of sensors, software, connectivity, and computing platforms, used across a range of medical and wellness applications. In medical applications, digital health technology can either be used as medical end-products or be separately incorporated with existing medical products. They are also used for the research and development (R&D) of other medical products [2]. Digital tools are expected to aid disease

prevention, early diagnosis, and the appropriate management of chronic diseases, along with providing opportunities to improve healthcare outcomes. Additionally, they also help to increase efficiency by enabling the patients to gain a holistic view of their health status. By giving them access to their healthcare data, digital health tools enable patients to take control of their health. Digital health is especially useful and prevalent in the treatment of diabetes mellitus.

Diabetes is a chronic disease characterized by elevated blood glucose levels, causing serious damage to the heart, blood vessels, eyes, kidneys, and nerves. Compared to other diseases, the treatment and management of diabetes necessitates the use of several medical devices such as syringes, insulin pens, and insulin pumps for drug administration, blood glucose-monitoring devices such as continuous glucose monitoring (CGM) and flash glucose monitoring (FGM) for disease management, and lifestyle guidance apps for diet and exercise [4]. Thus, information and communication technology (ICT) and digital health tools are particularly suitable for supporting diabetes treatment and care. Apps for nutrition, physical activity, glucose monitoring, insulin titration, and insulin delivery, along with devices such as an artificial pancreas, are some of the recent digital health tools that have emerged in diabetes care [4]. According to Research2Guidance [5], in addition to the existing healthcare companies, such as medical device and pharmaceutical companies, app service providers and data management solution providers are the new players in the digital health for diabetes sector. However, the characteristics and the classification of these new players in digital health for diabetes have not received sufficient attention.

### *1.2. Significance of Alliance Networks in Digital Health*

Understanding the characteristics of the new digital health players in the alliance network for diabetes is critical to predicting future developments in other disease areas. Digital health for diabetes aims to integrate and not substitute digital technology for healthcare providers. Therefore, to realize this goal, the existing electronic medical records and treatment and management methods must be integrated with digital data, and systems should be rebuilt to enable interoperable hardware. Digital therapy platforms could significantly support diabetes treatment and self-management through embedded algorithms [6]. Considering these developments, the existing healthcare companies, including medical device companies, will have to partner with technology companies that own digital therapy platforms, while forming a network centered on these technology companies. While technology companies can provide platform-based horizontal integration, pharmaceutical and medical device companies usually require vertical integration because their products are approved individually [7]. Therefore, it can be assumed that a network centered on technology companies is being formed in digital health in diabetes.

Several studies discussing the significance of alliance networks have argued that, in new technology domains, facilitating learning within alliance networks is crucial, and that being centrally located within such networks can increase the technology companies' competitive advantage [8–13]. Companies form alliances on the basis of their strategic intentions and actions; in turn, they benefit from the access to and exchange of information within their networks [8]. Alliance networks promote information diffusion, innovation, and learning opportunities for companies [9,10]. Additionally, by changing the flow of information and knowledge, these networks affect the companies' competitive advantage [11]. Hence, companies located at the center of an alliance network have a bigger impact than other firms in the network, due to their unique vantage point for disseminating information and knowledge, while also acting as a gateway for information exchange.

Previous research about network centrality has shown that the innovation output of firms increases with degree, eigenvector centrality, and number of structural holes it spans as the network parameters [14]. Therefore, it is important to measure the degree and the eigenvector centrality when we observe the alliance network related to innovation. In addition, previous research in the biotech or software industry has shown that alliances are formed on the basis of exploration and exploitation strategy according to the stage of new

product development of the firm [15,16]. In the exploration stage, a positioning in open network facilitates broad search for emerging innovations and future options which can increase performance variation, while, in the exploitation stage, a positioning in closed network yields access to redundant and validating information [17]. Since betweenness centrality measures the openness of a network position [17], it is thought that measuring betweenness centrality is important to infer the strategy of a company.

Therefore, wherever new technologies emerge in digital health, it is assumed that alliance networks are formed. In order to capture their characteristics, it is important to focus on degree, betweenness centrality, and eigenvector centrality, as shown in this research.

### *1.3. Aim and Objectives*

On the basis of the aforementioned background, the present study explored the characteristics of technology companies with high network centralities in their alliance networks for digital health in diabetes. The selected companies' alliance network was analyzed with respect to the changes in degree, betweenness, and eigenvector centralities in the recent decade. Thereafter, this study proposed three business model options to analyze the innovation mechanism in digital health.

## 2. Materials and Methods

We listed all the companies ($N$ = 57) according to the available public sources dealing with the industry trend of digital health [5,18,19]; then, we listed all the partnerships available from press releases of these companies. To identify the whole structure of the alliance network, newly emerged companies identified as partners in a press release were added to the list. This process was repeated until no new companies appeared. Lastly, we compiled a list of 231 companies and 331 contracts (Supplementary Materials Tables S1 and S2), and we referred to Crunchbase [20] to obtain information on company name, year of establishment, headquarter country, and company website, as well as to Bloomberg [21] for their sector and industry affiliations. Our company listing included partnerships with contracts released until 13 August 2020.

For network analysis, we used the open software package Gephi 0.9.2 [22], considering the selected companies as the nodes and the contracts as the edges. Thereafter, for each company, we calculated and extracted the degree, betweenness centrality, and eigenvector centrality as network parameters from 2011 to 2020 using Gephi 0.9.2. The definitions of these three network indicators were as follows: the degree centrality, the number of edges connected to the node; the betweenness centrality, the number of times a node lies on the shortest path between other nodes; the eigenvector centrality, the node's influence according to the number of links it has to other nodes in a network. The top-ranking companies were obtained through a graphical representation of the changes in the network centrality for each company.

## 3. Results

### *3.1. Changes in Degree of Each Company*

Figure 1 shows the change in degree of each company. The overall trend shows an increase in degree of each company over time, with high growth after 2015. In 2020, the following players had the highest degree: Medtronic (Midrand, South Africa) (healthcare sector: medical device and equipment industry), IBM Watson Health (Yorktown Heights and Albany, NY, USA) (technology sector: software and technology service industry), Dexcom Inc. (San Diego, CA, USA) (healthcare sector: medical devices and equipment industry), Verily (South San Francisco, CA, USA) and Novo Nordisk (Bagsværd, Denmark) (both healthcare sector: biotech and pharma industry), and Glooko (Mountain View, CA, USA) (technology sector: software and technology services industry). Therefore, among the existing players in the healthcare sector, two technology sector companies had a high degree.

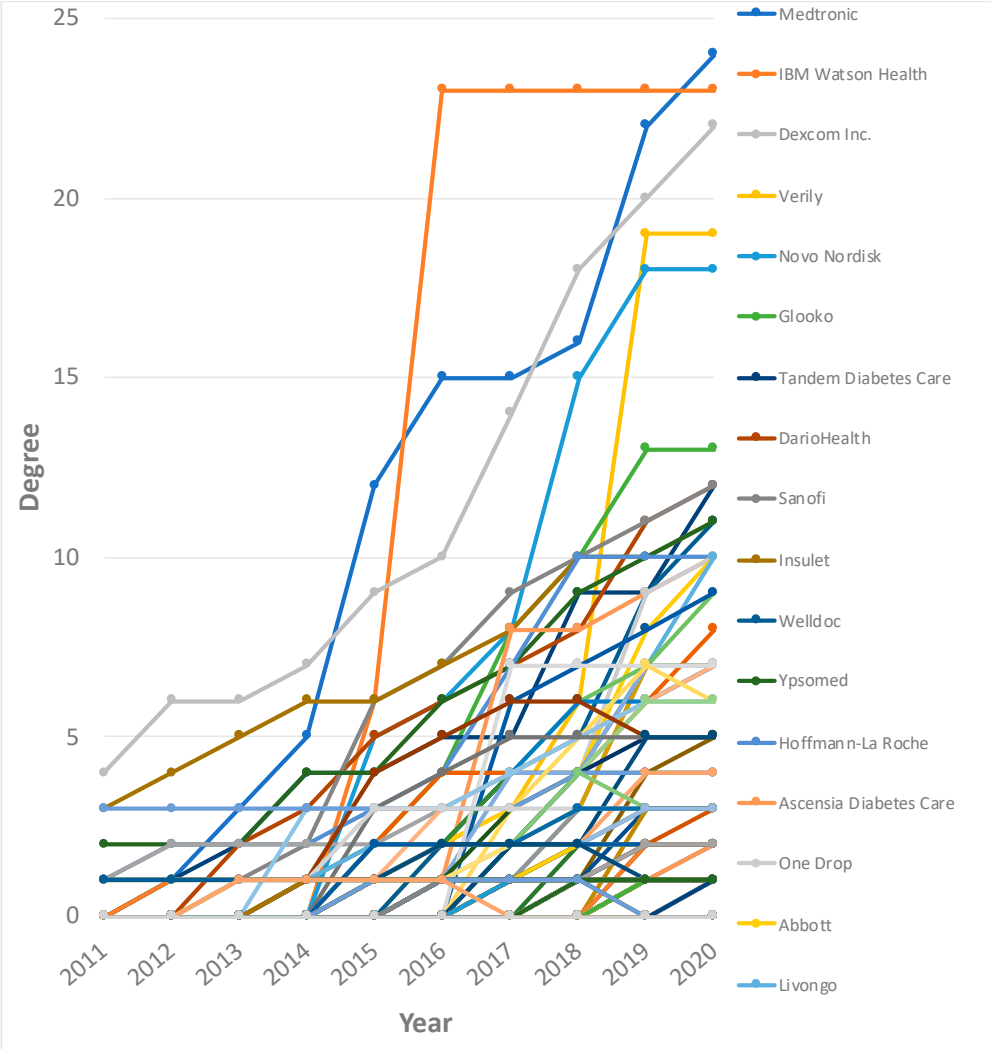


**Figure 1.** Historical changes in the degree of each company (2011–2020).

Dexcom Inc. has consistently maintained a high degree since 2011, whereas other high-ranking players in 2011 eventually decreased in rank. In addition to Dexcom Inc., other top-ranked players in 2020 (i.e., Medtronic, IBM Watson Health, Verily, Novo Nordisk, and Glooko) significantly improved their rankings after 2015.

### *3.2. Changes in Betweenness Centrality of Each Company*

Figure 2 shows the change in betweenness centrality for each company. The overall trends are similar to that of degree; that is, each company saw an increase in their betweenness centralities over time, especially after 2015.

Medtronic, Novo Nordisk, Dexcom Inc., IBM Watson Health, and Verily had the highest betweenness centralities in 2020.

Dexcom Inc. has consistently maintained a high betweenness centrality since 2011, whereas other players that had high betweenness centrality in 2011 decreased in rank. Additionally, the other top-ranking players in 2020 significantly improved their rankings after 2015.

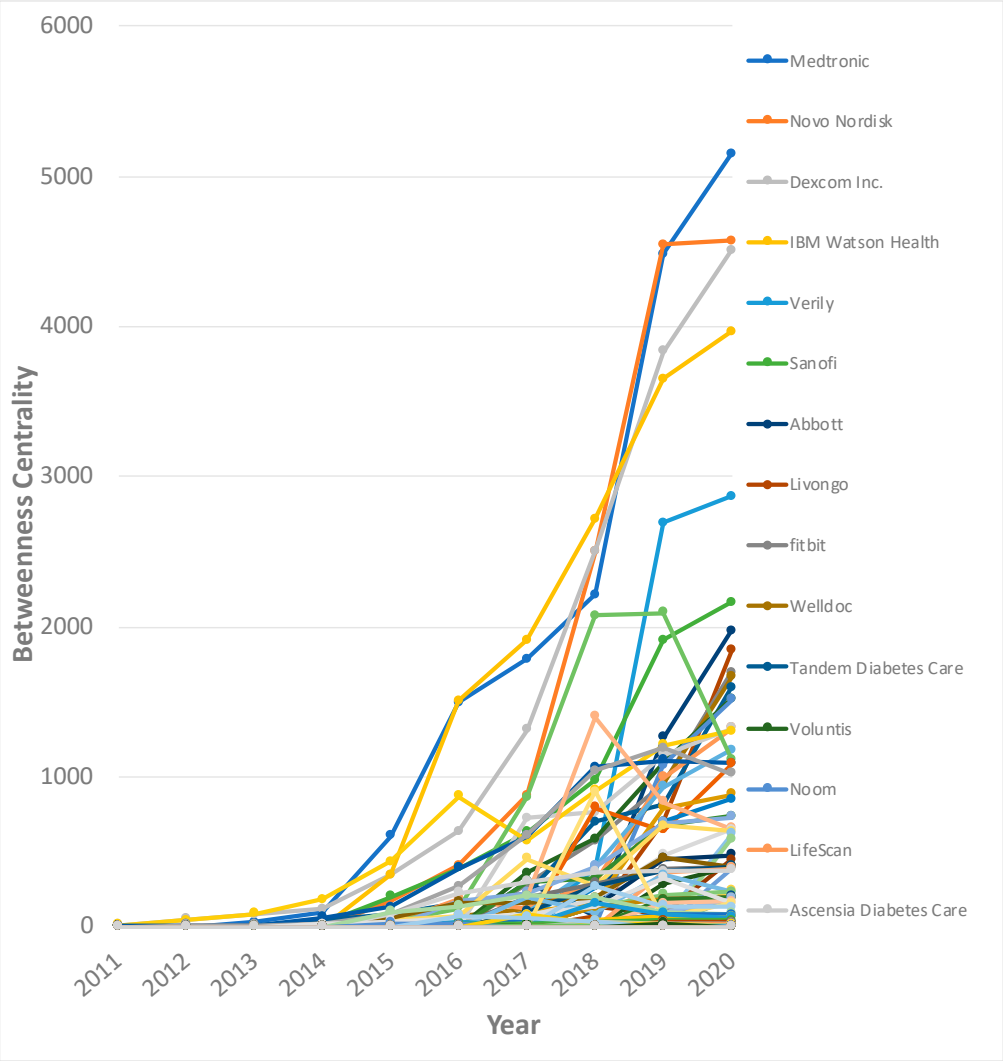


**Figure 2.** Historical changes in the betweenness centrality of each company (2011–2020).

### *3.3. Changes in Eigenvector Centrality of Each Company*

Figure 3 shows the change in eigenvector centrality for each company. Medtronic in 2015 and IBM Watson Health in 2016 saw a significant increase in their eigenvector centralities. However, Dexcom Inc showed a high eigenvector centrality both before 2015 and after 2016.

In 2020, Dexcom Inc, Medtronic, Glooko, Novo Nordisk, and Insulet (healthcare sector: medical devices and equipment industry) had the highest eigenvector centralities. Although IBM Watson Health ranked high in betweenness centrality, it ranked low in eigenvector centrality, whereas Glooko, which ranked low in betweenness centrality, showed a high eigenvector centrality in 2020.

As seen earlier, unlike other companies with high eigenvector centralities in 2011, Dexcom Inc. continued to maintain a consistently high position, while other top-ranking companies in 2020 saw a significant improvement in their rankings only after 2015.

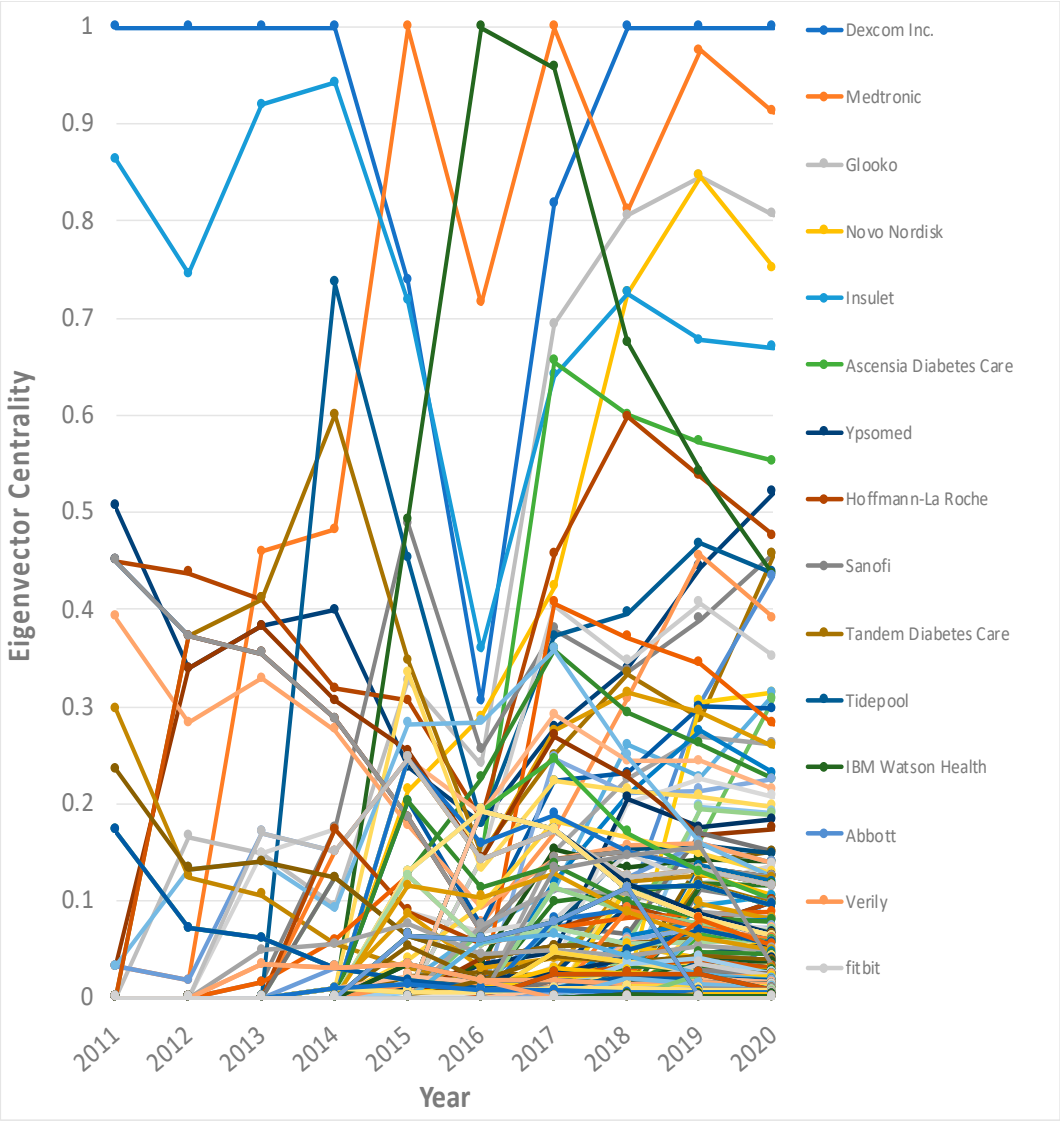


**Figure 3.** Historical changes in the eigenvector centrality of each company (2011–2020).

### *3.4. Characteristics of the Representative Companies*

Figure 4 shows a list of the 15 top-ranking companies for each network centrality parameter as of 2020. Notably, the companies headquartered in the US formed a majority of the list for all the measures (65%, 73%, and 67% in the degree, betweenness, and eigenvector centralities, respectively) and technology sector companies occupied a certain percentage of top companies (29%, 33%, and 20%, respectively). Overall, the following eight companies were identified as the top-ranked technology companies in degree, betweenness centrality, and eigenvector centrality: IBM Watson Health, Glooko, DarioHealth, Welldoc, OneDrop, Fitbit, Voluntis, and Noom, whereas, Medtronic, Dexcom Inc., and Novo Nordisk were identified as companies with a high network centrality in the healthcare sector.

(a)Degree

| Rank | Company | Location |
|---|---|---|
| 1 | Medtronic | USA |
| 2 | IBM Watson Health | USA |
| 3 | Dexcom Inc. | USA |
| 4 | Verily | USA |
| 5 | Novo Nordisk | Denmark |
| 6 | Glooko | USA |
| 7 | Tandem Diabetes Care | USA |
| 7 | DarioHealth | Israel |
| 7 | Sanofi | France |
| 10 | Insulet | USA |
| 10 | Welldoc | USA |
| 10 | Ypsomed | Switzerland |
| 13 | Hoffmann-La Roche | Switzerland |
| 13 | Ascensia Diabetes Care | Switzerland |
| 13 | One Drop | USA |
| 13 | Abbott | USA |
| 13 | Livongo | USA |

(b)Betweenness Centrality

| Rank | Company | Location |
|---|---|---|
| 1 | Medtronic | USA |
| 2 | Novo Nordisk | Denmark |
| 3 | Dexcom Inc. | USA |
| 4 | IBM Watson Health | USA |
| 5 | Verily | USA |
| 6 | Sanofi | France |
| 7 | Abbott | USA |
| 8 | Livongo | USA |
| 9 | fitbit | USA |
| 10 | Welldoc | USA |
| 11 | Tandem Diabetes Care | USA |
| 12 | Voluntis | France |
| 13 | Noom | USA |
| 14 | LifeScan | USA |
| 15 | Ascensia Diabetes Care | Switzerland |

(c) Eigenvector Centrality

| Rank | Company | Location |
|---|---|---|
| 1 | Dexcom Inc. | USA |
| 2 | Medtronic | USA |
| 3 | Glooko | USA |
| 4 | Novo Nordisk | Denmark |
| 5 | Insulet | USA |
| 6 | Ascensia Diabetes Care | Switzerland |
| 7 | Ypsomed | Switzerland |
| 8 | Hoffmann-La Roche | Switzerland |
| 9 | Sanofi | France |
| 10 | Tandem Diabetes Care | USA |
| 11 | Tidepool | USA |
| 12 | IBM Watson Health | USA |
| 13 | Abbott | USA |
| 14 | Verily | USA |
| 15 | fitbit | USA |

**Figure 4.** List of top companies in network parameters: (**a**) degree; (**b**) betweenness centrality; (**c**) eigenvector centrality. The names of technology sector companies are highlighted in blue. The companies headquartered in the US are highlighted in red.

The key characteristics of the eight selected technology companies are described below:

- *Glooko*

Glooko's main product, Glooko® Enterprise, is one of the largest diabetes data management platforms focusing on improving the lives of diabetes patients and their caregivers [23]. Glooko integrates the patient's medical data from CGM, insulin pumps, injection pens, and the activity data from wearable devices, and it provides clinical decision support to the physicians along with data and recommendations for their next therapeutic intervention. The proposed interventions follow the guidelines by the American Association of Clinical Endocrinologists and their clinical algorithms, contained in the Glooko system. Using Glooko's data, the physicians can make medical decisions and enter the decision information into Glooko's system to optimize the patient's diabetes treatment over a few weeks or months [24]. Glooko's platform solely focuses on diabetes care [23].

As of 2020, Glooko is connected with several medical devices and equipment companies such as Dexcom Inc., Medtronic, Insulet, Senseonics, and Companion Medical, biotech and pharma companies such as Novo Nordisk, Hoffmann-La Roche, Sanofi, and Ypsomed, a healthcare service facility called AMC Health, a software and technology company called DreaMed Diabetes, and other industry companies such as Ascensia Diabetes Care.

- *DarioHealth*

The main products of DarioHealth are myDario™ and DarioEngage™. DarioHealth uses technology and the science of behavior to create durable improvements in chronic disease, providing a personalized user experience at scale to make behavior change the path of least resistance. They leverage their early learning as a direct-to-consumer company to build the leading comprehensive digital health platform for providers, health plans, and benefits administrators. DarioHealth focuses on diabetes, hypertension, prediabetes, and musculoskeletal disease [25].

As of 2020, DarioHealth is connected with several medical equipment and devices companies such as Byram Healthcare, CCS Medical, InnoMed, uHealth Australia Pty Limited, Better Living Now, and Williams Medical, biotech and pharma companies such as Dance Biopharm and Centaur Pharmaceuticals, a healthcare facilities and services company called McCabi Healthcare, a retail and wholesale company called Giant Eagle, and other industry companies such as GEMCO Medical and Glytec.

- *Welldoc*

The main product of Welldoc is BlueStar®, which is FDA-cleared. Weldoc integrates advanced mobile technology, behavioral insight, and diabetes education for those living with type 2 diabetes, and it provides diabetes management. BlueStar® provides real-time and timely individualized coaching and support, as well as diabetes educational tools that are actionable and personal [26]. Welldoc focuses on diabetes, behavioral health, heart failure, hypertension, and prediabetes [27].

As of 2020, Welldoc is connected with LifeScan (medical equipment and devices company), Astellas (biotech and pharma company), Mass General Brigham (healthcare facilities and services), Voluntis, Redox, Solera Health, and Human API (software and technology services companies), Samsung (technology hardware and semiconductors company), Validic (telecommunications company), and Competitive Health and Business Healthcare Group as other industry companies.

- *Voluntis*

The main products of Voluntis for diabetes are Insulia® and Diabeo®. Voluntis uses digital platform, Theraxium, that transforms health data into medical intelligence for better care. For example, Insulia® provides automated basal insulin dose recommendations and coaching messages for people with type 2 diabetes while enabling the healthcare team to remotely monitor progress. This enables providers to deliver tailored telemedicine services, a practice increasingly supported by payers worldwide. Diabeo® provides therapeutic and decision-making support for effective diabetes management to help adult patients dose their basal and bolus insulin, facilitate interactions between patients and their healthcare professionals, and support remote management and the implementation of telemedicine services [28]. Voluntis focuses on diabetes, oncology, and immunology [29].

As of 2020, Voluntis us connected with Sanofi, Livongo, AbbVi,e and Biocon Biologics (biotech and pharma companies), Welldoc, Akili Interactive, and Salesforce (software and technology services companies), Propeller Health (media company), and other industry companies such as Ascensia Diabetes Care.

- *OneDrop*

The products of OneDrop are a smart glucose meter, adjustable lancing device, test strips, and a coaching and artificial intelligence (AI) forecasting service as a digital membership. OneDrop provides integration with thousands of apps and lets diabetes patients track their weight, A1C, medication, blood pressure, activity, glucose, and food all in one place [30]. The evidence-based platform offers affordable, accessible care to individuals, employers, insurers, and healthcare providers. OneDrop leverages proprietary machine learning, advanced AI, and personal health coaching to deliver customized programs that promote positive behavior change and drive outcomes [31]. OneDrop focuses on diabetes, prediabetes, high cholesterol, and high blood pressure [32].

As of 2020, OneDrop is connected with Sano and Companion Medical (medical equipment and devices companies), Bayer and MannKind (biotech and pharma companies), Springbuk (software and technology services company), Fitbit (technology hardware and semiconductors company), OneDigital and John Hancock (insurance companies), and Amazon and Walmart (retail and wholesale companies).

- *IBM Watson Health*

IBM Watson Health, in collaboration with Medtronic, has developed an application called Sugar.IQ, which can predict a patient's risk of hypoglycemia in the last 1–4 h. Its machine learning and pattern recognition algorithms analyze the patient's blood glucose levels, insulin data, hypoglycemic episodes, and food logs to predict and present the results regarding possible hypoglycemic events, enabling the patients to undertake preventive measures on the basis of the results [33]. In addition to diabetes, IBM Watson Health also focuses on providing digital healthcare for oncology, ophthalmology, central nervous system disease, and heart disease [34].

As of 2020, IBM Watson Health is connected with companies from diverse sectors such as Medtronic, Agfa HealthCare, and Hologic, Inc. (medical devices and equipment companies), Novo Nordisk and Johnson & Johnson (biotech and pharma companies), Anne Arundel Medical Center, Baptist Health South Florida, Radiology Associates of South Florida, Sentara Healthcare, Sheridan Healthcare, UC San Diego Health, the University of Miami Health System, the University of Vermont Health Network, and Phytel (health care facilities and services), and Explorys, Merge Healthcare, and Ifa Systems AG (software and technology services companies). Additionally, it has partnered with technology hardware and semiconductors companies such as Apple and Topcon, consumer discretionary services industry players such as Eastern Virginia Medical School and the American Diabetes Association, a retail and wholesale company called Inoveon, and another industry company called vRad.

- *Fitbit*

Fitbit produces smartwatches and active trackers and provides health coaching services [35]. It uses sensor and wireless technology for its wearable devices, designed to fit seamlessly into the customers' lives, to help them achieve their health and fitness goals [36]. It provides general health and wellness coaching for complex care/disease management, as well as program support for coaches targeting individuals with diabetes, hypertension, tobacco cessation, weight loss, etc. [37].

As of 2020, Fitbit is connected with companies such as Dexcom Inc. and Medtronic (medical devices and equipment), WellCare Health Plans (healthcare facilities and services), One Drop, Health2Sync, and Solera Health (software and technology services), and the FDA.

- *Noom*

Noom provides behavioral change programs. Noom's approach involves using cutting-edge technology such as artificial intelligence and behavioral coaching provided by more than 1000 personal health coaches to understand individual motivations and obstacles to good health. It also uses data and wellness insights to guide people toward sustainable change [38]. Noom's program showed weight loss efficacy in the prediabetic population [39]. It has potential for a scalable population healthcare management.

As of 2020, Noom is connected to companies such as LifeScan (medical devices and equipment), Novo Nordisk (biotech and pharma), CityMD and Jamaica Hospital Medical Center (health care facilities and services), EVERSANA (software and technology services), Samsung Ventures and Serena Ventures (financial services), and another industry company called CareConnectors.

## 4. Discussion

The previous sections showed the changes in degree, betweenness, and eigenvector centralities for each selected company from 2011 to 2020. We revealed that the network centrality rankings for companies with high network centrality showed a drastic transformation between 2011 and 2020. Notably, this period saw the rise of the technology sector companies, among which IBM Watson Health (Yorktown Heights and Albany, NY, USA), Glooko (Mountain View, CA, USA), DarioHealth (Caesarea, Israel), Welldoc (Columbia, MD, USA), OneDrop (New York, NY, USA), Fitbit (San Francisco, CA, USA), Voluntis (Suresnes, France), and Noom (New York, NY, USA) had the highest degree, betweenness, or eigenvector centralities as of 2020.

Among them, the betweenness centralities of IBM Watson Health, Fitbit, Welldoc, Voluntis, and Noom were higher than those of the others. Since betweenness centrality measures the openness of a network position, and since the positioning in the open network is related to the exploration stage [17], this suggests that these companies are positioned in open network and their product research and development stage is in exploration. On the other hand, Glooko, DarioHealth, and OneDrop had high degree but lower betweenness

centrality than the others. This suggests that these companies are positioned in closed network and their product research and development stage is in exploitation [17].

Next, we discussed the customer value provided by these technology companies in terms of three models (Figure 4).

### *4.1. Intermediary Model*

Figure 5a shows Glooko's digital health model, wherein Glooko's products and services are characterized by their position as the de facto standard for vertical compatibility. In other words, it can be connected to any type of hardware device, which distinguishes it from other companies [40]. Additionally, regardless of the type of CGMs, insulin pumps, insulin pens, and wearable devices used, the patients and physicians can continue to use Glooko even if the physician changes the treatment plan and/or the device. Thus, device compatibility is an important managerial concern for the implementation of a standardization strategy based on compatibility for companies providing digital health, as also observed, for example, in the field of cell and gene therapy [41].

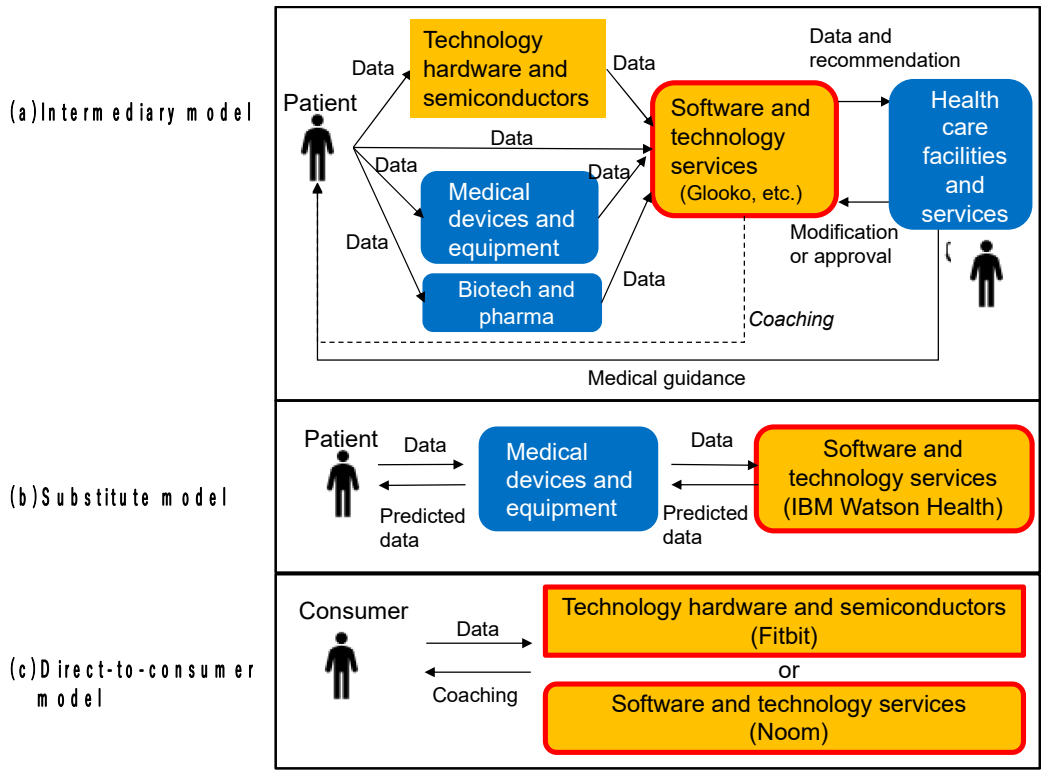


**Figure 5.** Value delivery model in three types of technology sector companies. (**a**) The intermediary model is represented by Glooko, DarioHealth, Welldoc, Voluntis, and OneDrop, (**b**) the substitute model is represented by IBM Watson Health, and (**c**) the direct-to-consumer model is represented by Fitbit and Noom.

DarioHealth, Welldoc, OneDrop, and Voluntis have similar models, with some differences.

### *4.2. Substitute Model*

Figure 5b shows IBM Watson Health's digital health model. This value delivery model aims to predict risks through several partnerships with healthcare facilities for prevention research, the establishment of a unique network, and the operation of AI-based prediction for disease onset and deterioration. IBM Watson Health's role is to add value to Medtronic's medical devices. Additionally, it was the first to introduce a prediction technology to the market by focusing on the patients rather than the non-patients.

IBM Watson Health was ranked second in degree centrality as of 2020; however, it ranked lower for eigenvector centrality, as it has partnerships with at least nine healthcare

facilities out of the total 24 companies listed in this study. This company's model seems to focus on predicting the onset and risk of diabetes, finding prevention methods using AI technology, and building their network with healthcare facilities to achieve their goal.

### *4.3. Direct-to-Consumer Model*

Figure 5c shows Fitbit and Noom's model, which caters to both patients and non-patients. The companies' products utilize the data directly obtained from the customers and, in turn, provide services such as data visualization and/or health coaching. The difference between this model and the other two models discussed earlier is that the customers are not limited to diabetes patients; it can still be used also for the prevention of diabetes. In fact, clinical trials have shown that Noom's diabetes prevention program promotes weight loss [39]. Such preventive interventions are expected to accelerate in the future. As these interventions are directly aimed at the patients, they are expected to be incorporated into the Glooko ecosystem. Additionally, this model is unique because, while it started in the realm of wellness, it is now being used to provide complete healthcare.

Lastly, we discuss the limitations of this study and implications of the findings for the future. An accurate understanding the innovation mechanism in the field of digital health requires expanding the focus on factors other than business alliances. In particular, although the human network of each company's management team was not considered in the present study, it is considered an essential source of firms' innovative activities. Therefore, there is scope for deepening the understanding of these companies' innovation mechanisms using human networks. Nevertheless, to the best of our knowledge, this is the first case study to highlight the characteristics of companies with high network centralities in the field of digital health, which is expected to contribute to the understanding and promotion of the innovation mechanisms in digital health. In addition, this study focused on the field of diabetes. More extended studies including other diseases might confirm the generalizability of these findings and would contribute to the further promotion of digital health.

## 5. Conclusions

The present study explored the significance of business alliances for innovative activities in digital health. We observed the historical changes of network centrality of each company focusing on diabetes and characterized the technology companies with higher network centralities as representative examples. First, we found that the companies' rankings for the three centrality measures showed considerable variation from 2011 to 2020, during which the technology companies strengthened their positions. Regarding the characteristics of the eight representative companies, Glooko's compatibility with multiple devices proved to be a significant competitive advantage, resulting in an increased eigenvector centrality. IBM Watson Health's high degree centrality was driven by its proprietary AI technology and partnerships with multiple healthcare facilities to build its R&D network for preventive medicine. Fitbit and Noom provided the advantage of both prevention and disease management, with a direct network to their consumers. Lastly, we structured these findings into three business models, highlighting the companies' customer value: (i) intermediary model, (ii) substitute model, and (iii) direct-to-consumer model. This study's findings and discussion are expected to contribute toward building knowledge on the business ecosystems in the digital era while providing practical solutions for business development in digital health.

**Supplementary Materials:** The following are available online at https://www.mdpi.com/article/10.3390/su13094839/s1, Table S1. List of companies in diabetes digital health. Table S2. List of contracts in diabetes digital health.

**Author Contributions:** Conceptualization, S.K.; methodology, S.K.; formal analysis, S.K.; writing—original draft preparation, S.K.; writing—review and editing, S.K., K.K., and S.S.; supervision,

S.S.; funding acquisition, K.K. All authors have read and agreed to the published version of the manuscript.

**Funding:** This research was financially and partially supported by MEXT/JSPS KAKENHI (the Grant-in-Aid for Scientific Research, 20H01546 and 21H00739), Japan.

**Data Availability Statement:** Data sources are listed in the reference section and in Supplementary Materials Tables S1 and S2.

**Conflicts of Interest:** The authors declare no conflict of interest.

## References

1. Meister, S.; Deiters, W.; Becker, S. Digital health and digital biomarkers—Enabling value chains on health data. *Curr. Dir. Biomed. Eng.* **2016**, *2*, 577–581. [CrossRef]
2. Digital Health Center of Excellence. Available online: https://www.fda.gov/medical-devices/digital-health (accessed on 30 June 2020).
3. The Power of Digitalizing Health Care. Available online: https://cdn0.scrvt.com/39b415fb07de4d9656c7b516d8e2d907/1800000004474496/0a61bcfdca1f/HOOD05162002713103_HBR_Digitalizing_Healthcare_SH_slim_1800000004474496.pdf (accessed on 11 January 2021).
4. Fleming, G.A.; Petrie, J.R.; Bergenstal, R.M.; Holl, R.W.; Peters, A.L.; Heinemann, L. Diabetes digital app technology: Benefits, challenges, and recommendations. A consensus report by the European Association for the Study of Diabetes (EASD) and the American Diabetes Association (ADA) Diabetes Technology Working Group. *Diabetologia* **2020**, *63*, 229–241. [CrossRef] [PubMed]
5. Who Are the Digital Diabetes Market Players that Transform the Diabetes Industry? Available online: https://research2guidance.com/digital-diabetes-industry-is-growing-quickly-and-attracting-new-niche-players/ (accessed on 11 January 2021).
6. Kerr, D.; King, F.; Klonoff, D.C. Digital Health Interventions for Diabetes: Everything to Gain and Nothing to Lose. *Diabetes Spectr.* **2019**, *32*, 226–230. [CrossRef] [PubMed]
7. Pisano, G.P. *Science Business: The Promise, the Reality, and the Future of Biotech*; Harvard Business School Press: Boston, MA, USA, 2006.
8. Soh, P.-H. Network patterns and competitive advantage before the emergence of a dominant design. *Strat. Mgmt. J.* **2010**, *31*, 438–461. [CrossRef]
9. Liebeskind, J.P.; Oliver, A.L.; Zucker, L.; Brewer, M. Social networks, learning and flexibility: Sourcing scientific knowledge in new biotechnology firms. *Organ. Sci.* **1996**, *7*, 428–443. [CrossRef]
10. Powell, W.W.; Koput, K.W.; Smith-Doerr, L. Interorganizational collaboration and the locus of innovation: Networks of learning in biotechnology. *Adm. Sci. Q.* **1996**, *41*, 116–145. [CrossRef]
11. Owen-Smith, J.; Powell, W.W. Knowledge networks as channels and conduits: The effects of spillovers in the Boston biotechnology community. *Organ. Sci.* **2004**, *15*, 5–21. [CrossRef]
12. Powell, W. Learning from collaboration: Knowledge and networks in the biotechnology and pharmaceutical industries. *Calif. Manag. Rev.* **1998**, *40*, 228–240. [CrossRef]
13. Reiko Onodera and Shintaro Sengoku. Innovation process of mHealth: An overview of FDA-approved mobile medical applications. *Int. J. Med. Inform.* **2018**, *118*, 65–71. [CrossRef] [PubMed]
14. Ahuja, G. Collaboration Networks, Structural Holes, and Innovation: A Longitudinal Study. *Adm. Sci. Q.* **2000**, *45*, 425–455. [CrossRef]
15. Rothaermel, F.T.; Deeds, D.L. Exploration and exploitation alliances in biotechnology: A system of new product development. *Strateg. Manag. J.* **2004**, *25*, 201–221. [CrossRef]
16. Lavie, D.; Rosenkopf, L. Balancing Exploration and Exploitation in Alliance Formation. *Acad. Manag. J.* **2006**, *49*, 797–818. [CrossRef]
17. Baum, J.; Cowan, R.; Jonard, N. Does evidence of network effects on firm performance in pooled cross-section support prescriptions for network strategy? *Strateg. Manag. J.* **2014**, *35*, 652–667. [CrossRef]
18. Top 10 Companies in Digital Diabetes Devices Market. Available online: https://meticulousblog.org/top-10-companies-in-digital-diabetes-devices-market/ (accessed on 13 August 2020).
19. Top Diabetes Companies on the Way to the Artificial Pancreas. Available online: https://medicalfuturist.com/top-diabetes-companies/ (accessed on 13 August 2020).
20. Available online: https://www.crunchbase.com (accessed on 24 December 2020).
21. Available online: https://www.bloomberg.com/asia (accessed on 24 December 2020).
22. Available online: https://gephi.org (accessed on 20 August 2020).
23. Available online: https://www.glooko.com/clinics-and-health-systems/ (accessed on 23 March 2021).
24. Glooko Announces New 'Glooko Advise' Decision Support Product Line at the 2016 American Diabetes Association Conference. Available online: https://www.glooko.com/press-release/glooko-announces-new-glooko-advise-decision-support-product-line-at-the-2016-american-diabetes-association-conference/ (accessed on 13 January 2021).

25. DarioHealth Investor Presentation in 2021. Available online: https://filecache.investorroom.com/mr5ir_mydario/292/Dario%20Health%20-%20Corp%20Deck.pdf (accessed on 23 March 2021).
26. WellDoc's Digital Platform for Type 2 Diabetes Powers "Diabetes Wellness Program" Within Samsung Health. Available online: https://www.welldoc.com/news/samsung-health-diabetes-wellness-program/ (accessed on 23 March 2021).
27. Available online: https://www.welldoc.com/product/ (accessed on 23 March 2021).
28. Available online: http://www.voluntis.com/en/about-us (accessed on 23 March 2021).
29. Voluntis Company Presentation in March 2021. Available online: http://www.voluntis.com/files/investors/documents_a_telecharger/voluntis_management_presentation_2021_03_v20210310_en_vdef.pdf (accessed on 23 March 2021).
30. Available online: https://onedrop.today/collections/bundle-1 (accessed on 23 March 2021).
31. One Drop Media Kit. Available online: https://onedrop.today/pages/media-kit (accessed on 23 March 2021).
32. Available online: https://onedrop.today/pages/employer (accessed on 23 March 2021).
33. Alleviating the Burden of Diabetes with AI. Available online: https://www.ibm.com/blogs/think/2019/01/alleviating-the-burden-of-diabetes-with-ai/ (accessed on 13 January 2021).
34. Medical Imaging Leaders Tap IBM and Watson to Tackle Cancer, Diabetes, Eye Health, Brain Disease and Heart Disease. Available online: https://mednax.gcs-web.com/news-releases/news-release-details/medical-imaging-leaders-tap-ibm-and-watson-tackle-cancer (accessed on 23 March 2021).
35. Available online: https://www.fitbit.com/global/us/products (accessed on 23 March 2021).
36. Available online: https://www.fitbit.com/global/us/about-us (accessed on 23 March 2021).
37. Fitbit Now Offers 1:1 Health Coaching. Available online: https://healthsolutions.fitbit.com/healthcoaching/ (accessed on 23 March 2021).
38. Novo Nordisk Announces Obesity Digital Health Tie-Up within Noom. Available online: https://pharmaphorum.com/news/novo-nordisk-announces-obesity-digital-health-tie-up-with-noom/ (accessed on 23 March 2021).
39. Michaelides, A.; Raby, C.; Wood, M.; Farr, K.; Toro-Ramos, T. Weight loss efficacy of a novel mobile Diabetes Prevention Program delivery platform with human coaching. *BMJ Open Diabetes Res. Care* **2016**, *5*, e000264. [CrossRef] [PubMed]
40. New Glooko CEO: Livongo Gets a Lot of Press but Our Approach Is Different. Available online: https://medcitynews.com/2018/05/new-glooko-ceo-livongo-gets-a-lot-of-press-but-our-approach-is-different/?rf=1 (accessed on 13 January 2021).
41. Sengoku, S.; Sumikura, K.; Oki, T.; Nakatsuji, N. Redefining the Concept of Standardization for Pluripotent Stem Cells. *Stem Cell Rev. Rep.* **2011**, *2*, 221–226. [CrossRef] [PubMed]