Crowd Profile: Research and Review on Diabetes Mellitus Health Management

Longfeng Weng, Zhongyan Lin*
International Digital Economy College, Minjiang University, Fuzhou, Fujian, China
**Corresponding Author.*

Abstract: Diabetes Mellitus is a paradigmatic case of long-term care, being one of the most prevalent chronic diseases worldwide, with millions of patients with no cure. Health management is pivotal in addressing diabetes; however, the lack of personalized and tailored diabetes intervention and self-care management strategies has prevented patients from maximizing health outcomes. The crowd profile technique, an effective tool for user analysis, combines artificial intelligence and big data analytics to provide diabetes risk prediction, personalized health management, and digital consultation services for patients with diabetes. This study reviews the current research on the application of the crowd profile in diabetes health management, highlighting the potential benefits and challenges associated with crowd profile in diabetes management. The findings underscore the critical need for integrating crowd profile into healthcare systems to enhance the quality and effectiveness of diabetes health management.

Keywords: Crowd Profile; Health Management; Diabetes Mellitus; Risk Prediction; Digital Consultation

1. Introduction

Diabetes Mellitus is one of the most widespread chronic diseases worldwide, with its prevalence rate rising year by year, placing significant pressure on public healthcare systems all around the world. According to the International Diabetes Federation, approximately 537 million adults globally are living with diabetes, and this number is expected to climb to 783 million by 2045 [1]. In China, there are over 140 million patients with diabetes, making it the country with the largest number of diabetes patients in the world. Additionally, the prevalence rate of diabetes among Chinese adults (aged 20-79) is projected to rise from 8.2% to 9.7% between 2020 and 2030, leading to a dramatical increase in overall diabetes expenses, from $250 billion to $460 billion. That is, an annual growth rate of 6.32%, which overpasses China's GDP growth, resulting in considerable economic burden [2]. Diabetes raises the risk for damages to the eyes, kidneys, nerves, and heart, potentially link to some types of cancer [3]. Therefore, diabetes complications pose serious threats to individuals' quality of life, imposing heavy healthcare burdens on society. Effective diabetes health management, including lifestyle interventions, medical intake and diet adjustment, plays a vital role in reducing the occurrence and severity of diabetes complications, and therefore has a substantial impact on population health.

The emerging of digital technologies, particular the rise of artificial intelligence, big data analytic, and the Internet of Things, has offered unprecedented opportunities to enhance diabetes management and improve health outcomes. Crowd profile, through analyzing patients' lifestyle, health data, and behavioral patterns, offers new channels for disease risk prediction, health management and digital diagnosis [3,4]. Despite the extensive scope of previous research, given the lightning pace of technological development and the subsequent surge in application, systematic reviews of crowd profile in diabetes intervention and management are needed. This study provides a comprehensive overview of the current applications of crowd profile in diabetes management, analyzes its role in diabetes risk prediction, health management, and digital diagnosis, and aims to identify benefits and challenges.

2. Crowd Profile

This section introduces the concept of the crowd profile technique, highlighting the

construction processes of crowd profiling in practice (Figure 1).

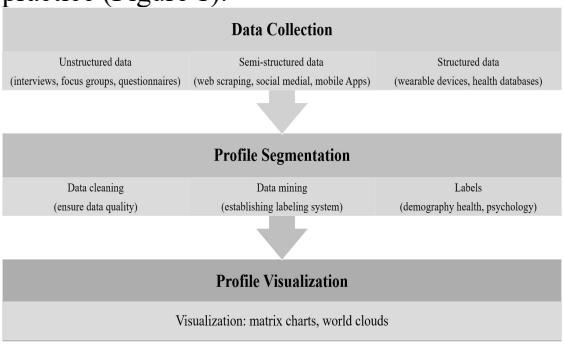

Figure 1. Crowd Profiling Process

2.1 The Concept of Crowd Profile

Crowd profile is a visualization modeling technique based on real user data. By analyzing large volumes of user data, crowd profile extracts behavior patterns, health status, and lifestyles to provide insights into health risks for both individuals and groups. Originally derived from the IT field, it was first used to construct target user group profiles by analyzing user behaviors and interests [5] The crowd profile technique has been widely applied in various fields, including marketing, software development, higher education, robotics, videogames and healthcare [6].

Recent advances in digital technologies have opened unprecedented opportunities for utilizing crowd profiles in diabetes prevention and management [4]. By analyzing the lifestyles, health behaviors, and medical records of high-risk individuals and patients with diabetes, “profiles of high-risk diabetes populations” or “profiles of diabetes patients” are generated. These profiles assist healthcare professionals and public health departments in gaining a better understanding of the health profiles of different populations, enabling the development of precise health management and disease prevention plans [7].

2.2 Crowd Profile Construction

The construction of crowd profile generally includes data collection, profile segmentation, and profile visualization:

2.2.1 Data collection.

Based on the data source of diabetes, crowd profile data collection consists of three types. That is, qualitative or unstructured data (e.g., interviews, focus groups, questionnaires), semi-structured or partially quantitative data (e.g., web scraping, social media, mobile application), and fully structured data (e.g., wearable devices, health-related database) [6].

2.2.2 Profile segmentation.

Once data collection is completed, individuals will be segmented into groups based on their shared traits, enabling the creation of profiles for each group. Specifically, data cleaning is applied to remove duplicates, missing values, and invalid data to ensure data quality and accuracy. Then, data mining algorithms were employed to extract heath characteristics from the collected data, thereby establishing a labeling system for the crowd portrait. Common methods for profile generation include Bayesian networks, topic modelling, association rule learning, label rating, clustering analysis, and social network analysis [7]. Meanwhile, common labels in crowd profile include demographic data (e.g., age, gender), health behaviors (e.g., diet, exercise), and psychological characteristics (e.g., emotional tendencies) [6]. Portrait segmentation is the core step in crowd portrait construction, and it is crucial to set reasonable accuracy limits to avoid over-cleaning, which can result in mis-representation of data sample [8].

2.2.3 Profile visualization.

This step refines relevant feature based on the results from portrait segmentation to develop the crowd profiles. Various visualization tools, such as world clouds and matrix charts, are used to present the health needs and attribute correlations of the study crowd in a clear manner [6].

3. The Application of Crowd Profile in Diabetes Health Management

As a chronic disease, diabetes requires effective lifestyle interventions and management through daily behavior adjustments and improved self-care [2]. In practice, the crowd profile leverages health-related data to analyze future risk factors of the targeted population (e.g., diabetic retinopathy, nephropathy) [9]. Furthermore, the crowd profile facilitates the development of customized diabetes interventions based on the needs, goals, and life experiences of diabetic patients [10]. This not only enhances the relevance of educational efforts but also enables patients to perform self-management more efficiently under the guidance of evidence-based medicine, achieving a more

proactive and scientific approach to diabetes self-management [11]. Additionally, by integrating patients' physiological data (e.g., blood glucose level) and medication usages, the crowd portrait supports doctors in generating more precise medical decisions [3] (Figure 2).

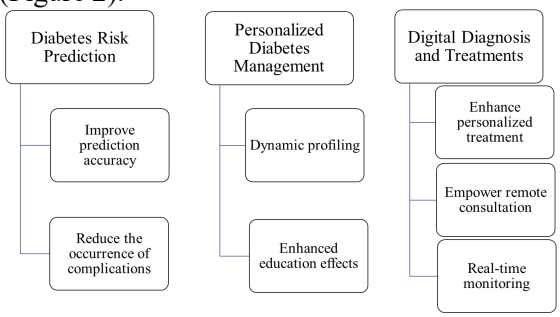

Figure 2. Crowd Profiling in Diabetes Management

3.1 Diabetes Risk Prediction

Diabetes is a chronic metabolic disease that, as it progresses, is prone to complications involving infectious diseases, micro- and macro-vascular complications, neurological complications, and diabetes foot. These complications severely reduce patients' quality of life, whereas increasing both the disease and economic burdens [4]. Therefore, early prediction and detection of diabetes risk factors as well as progressions are particularly important [12].

On the one hand, the data-driven crowd profile technique extracts diabetes risk factors from data related to patients' medical behavior and disease progression, predicting potential complications and issuing warnings [3]. Crowd profile, empowered by data mining, has been applied to predict the risk of diabetes onset and provide early warnings even before patients exhibit noticeable symptoms [13]. Machine learning models, such as neural network models, achieve over 97% accuracy in predicting early symptoms of diabetes [9]. In addition, integrating with big data analytic, crowd portrait examines factors include family medical history, body mass index, and blood glucose levels, enabling the model to predict the likelihood of a patient developing diabetes within the next few years [10].

On the other hand, crowd profile integrates with artificial intelligence facilitates doctors intervening the diabetes in its early stage, reducing the occurrence of severe complications [7]. Large language models, as an application of generative artificial intelligence, can analyze user data which includes patients' genetic background and physiology indicators. This enables early detection of contributors to the development of diabetes, providing timely warnings for at-risk groups [14]. In addition, data mining techniques, such as random forest and support vector machine, have been used to predict the likelihood of diabetes occurrence based on historical data, helping doctors intervene in advance and thereby reducing the medical burden caused by the disease [10]. In Internet Plus era, big data technology is used to extract text messages left by users in online communities and social media platforms. Through text analysis, big data empowered crowd profile can obtain labels related to users' emotions, disease conditions, and behaviors, enabling the identification of different types and stages of diabetes patients and providing personalized recommendations [13].

In summary, crowd profile technique not only collects health data on diabetic patient groups, but also integrates demographic data, lifestyle factors, genetic background, and environmental factors to construct a labeled profiling model for high-risk diabetes populations. This effectively improves the accuracy of diabetes risk prediction while reduces the occurrence of diabetes complications.

3.2 Personalized Diabetes Management

Self-management is an essential component in the management of noncommunicable diseases, such as diabetes, highlighting personal accountability in avoiding preventable unhealthy behaviors and adapting to both medical and emotional aspects. Education and support for diabetes self-management establish a basis for individuals with diabetes to manage their care independently, promoting improved physical health, a higher quality of life, and better glycemic outcomes. The conventional diabetes management is static, and usually delivered to patients through diabetes knowledge lectures, health management videos, and educational articles during their clinical visits and hospital stays [15,16]. Crowd profile facilitates the conventional diabetes managements with more personalized and dynamic health-care interventions, improving the effectiveness of health managements.

Crowd profile based on real-time data provides dynamic profiling for diabetes groups. The development of wearable devices and mobile health applications (mHealth) facilitates real-time monitoring of patients' health data. These technologies enable the collection of real-time health metrics such as blood glucose and heart rate, which are then analyzed to create real-time health profiles for users, providing instant feedback and personalized intervention suggestions. For example, by tracking patients' blood glucose levels, weight changes, and dietary patterns, high-risk individuals can be identified early, and interventions can be implemented to mitigate or prevent the development of diabetes complications [3]. Data-driven methods have been used to construct and validate various self-management crowd profiles for type 2 diabetes, providing strong support for developing targeted intervention strategies, designing mobile health products, and improving system usability and acceptance [16]. By quantifying users' explicit emotional keywords, population profiling models can analyze the psychological changes of diabetes patients to provide real-time psychological monitoring [14,17].

Currently, the diabetes self-management education is usually provided by medical staff to patients and their families during their hospital stays or clinical visits, where health education is delivered through. Despite these education forms have shown some effectiveness in achieving patients' health improvements, their content is generally limited, preventing patients from accessing systematic, detailed and personalized health knowledge [11]. On the contrary, the diabetes health management based on crowd profile allow quick and accurate recommend health knowledge to patients. Moreover, crowd profile empowered health education method adjusts the frequency and quantity of recommended knowledge based on patients' characteristics [15], preventing information overload that might discourages patients from obtaining health information. In addition, crowd profile provides medical staffs an innovative approach customizes diabetes management based on the needs of the diabetic population. Empirical studies have demonstrated that the crowd profile technique is widely applied in the domain of health management education, facilitating the timely delivery of professional knowledge to patients, thereby enhancing their health literacy and self-management capabilities [18].

3.3 Digital Diagnosis and Treatments

With the exponential growth of the Internet in recent years, crowd profile has been applied in empowering digital diagnosis and treatment services in diabetes management.

Crowd profile technique enhances personalized treatment services. Compared to conventional diabetes treatments, data-driven medical decision makings which based on crowd profile technique can significantly improve the effectiveness of diabetes treatment plans while avoiding over- or under-treatment [7,14]. The management of diabetic patients requires tailored treatment plans based on individual needs. Through crowd profiling, doctors can gain deeper insights into patients' electronic health records, genetic data, medical history, lifestyle habits, and exercise routines, thereby developing personalized treatment plans. In practice, crowd profile not only helps distinguish between different types of patients (e.g., Type 1 diabetes, Type 2 diabetes, and gestational diabetes) [9], but also enables the development of personalized medication plans based on individual differences (e.g., age, weight, blood glucose levels, and complications) [13,14]. Additionally, by constructing crowd profiles based on the frequency and intensity of patients browsing information online, it is possible to understand their healthcare needs and offer personalized medication, disease treatment knowledge, and detailed dietary plans [12].

The crowd profile technique can empower remote consultation and monitoring services. Crowd profile technique features with constant updates and instantaneous responses, facilitating diabetes consultation systems design to reduce repetitive questions and provide specific advice and feedback that patients need in a timely manner, improving user satisfaction. Combining with artificial intelligence such as natural language processing, has been applied to writing patient clinical information and accurately recording communication between doctors and patients. For example, OpenAI's ChatGPT is already capable of generating clinical information that is easy for patients to understand, enhancing communication efficiency, accuracy, and

patient satisfaction while reducing healthcare system costs [19].

The rise of Internet of Things technology has enabled the real-time monitor the health conditions of diabetic patients [18]. Through wearable devices, data such as blood sugar levels, heart rates, and physical activities can be automatically uploaded to health management systems. With the assistance of artificial intelligence and data mining techniques, the health status of diabetic patients can be monitored in real time, creating user-center crowd profiles. This real-time monitoring not only improves the efficiency of diabetes management but also provides technical support for telemedicine [11].

In summary, crowd profile technique collects and analyzes patient health behavior data to create personalized medication management plans, thereby enhancing patient adherence. The emerging of wearable devices facilitates monitoring of patients' health data in real time. Thus, a digital monitoring system based on crowd profile can help patients develop self-management habits through reminders and encouragement mechanisms.

4. Challenges and Future Development

4.1 Data Privacy and Security

With the widespread of crowd profile, the privacy and security of patient data have become increasingly important [11]. Since crowd profile involves processing large amounts of personal health data, ensuring that patient privacy is not violated is a significant challenge [14]. To protect personal privacy, only a portion of the data is currently being effectively utilized. Balancing medical data sharing with patient privacy protection is a vital issue that developers and administrators need to consider [20]. Additionally, the occurrence of data leaking scandals has also led to the loss of user ownership and control over their data [11]. Combined with security vulnerabilities in the digital platforms, this has raised concerns among diabetic users about the privacy breaches associated with crowd profile [7].

Therefore, the use of crowd profile technique should focus on the actual needs of the profiling population, and achieve precise data delivery. From a technical perspective, techniques such as data de-identification, blockchain, and hidden tags should be employed to further enhance the data security [14]. Companies, equipment suppliers, and medical institutions should strengthen cooperation with network providers, introduce advanced information technologies, and establish dedicated cybersecurity systems [7]. In the meanwhile, it is recommended that the government should improve data security regulations for crowd profile to ensure the privacy and security of patient, reducing patients' concerns and thus increasing their willingness to use crowd profile.

4.2 Operating Costs and Technology Adoption

Currently, crowd profile has been widely applied in high-income regions and large medical institutions. However, in regions with limited resources or in small and medium sized medical institutions, the cost of technology and infrastructure construction remain significant factors limiting its application [11]. On the one hand, crowd profiling data differs from traditional data types, typically presented in a mixed form of structured, semi-structured, and unstructured data. With the widespread use of multimedia formats such as images, audio, and video, the demand for storage space for profiling data has increased dramatically [7]. Whether it is the structured conversion of semi-structured and unstructured data or the optimization of storage for massive profiling data, a systematic management mechanism needs to be established to address the diversity and variability of data. In addition, user characteristics and information change over time [4]. Therefore, to keep up with real-time user demand characteristics and provide corresponding feedback, crowd profiles need to be updated in real time and maintained regularly. On the other hand, the current population of diabetes patients has varying levels of education, and a significant proportion consists of rural residents and the elderly in China. This group also has a clear digital divide with the mainstream digital population [2], limiting the promotion of crowd profiling.

It is recommended that the government should encourage social capitals to participate in the digital construction of primary healthcare institutions through policies such as subsidies and tax incentives, thereby continuously

promoting both the construction and coverage of crowd profile based digital health infrastructure. In addition, private enterprises and social organizations should be incentivized to conduct innovative research on health digitalization applications, promote the development of technologies for storing, analyzing, and processing crowd profile data, established models and knowledge databases. Furthermore, consideration should be given to including crowd profile systems, platforms, and equipment that meet standards within the scope of medical insurance reimbursement to enhance fairness and accessibility [1]. Meanwhile, support for primary healthcare institutions should be strengthened by increasing incentives and subsidies for medical personnel, thereby improving their work enthusiasm and satisfaction for providing crowd profile-based diabetes education to patients.

4.3 The Demand for Dynamic Management

Although scholars have employed Internet of Things-based wearable devices to achieve dynamic updates of crowd profile [21], the application of crowd profile in the management of diabetes and chronic diseases is still limited. The health status of diabetic patients is likely to change over time [12], so the crowd profile needs to be updated accordingly to ensure the effectiveness of the personalized diabetes management. Compared to the static crowd profile, the dynamic crowd profile can continuously track the health status of diabetic patients and updating profile labels to achieve dynamic diabetes management [11]. Therefore, future crowd profile should continuously track user data, update profile labels in a timely manner, and integrate user feedback to comprehensively evaluate and improve the profiling effectiveness [6]. In addition, dynamic maintenance and iteration of crowd profiling should be carried by establishing associated databases and incorporating into routine management tasks. Finally, current research on dynamic crowd profile for diabetes primarily focuses on dynamic blood sugar indicators, with a lack of analysis including patient medication, physical, and psychological conditions [6]. Future studies should consider incorporating more physiological and biochemical indicators as research variables to verify and improve the application of crowd profile in diabetes management.

5. Conclusion

Challenges such as "global aging," surging medical costs, overburdened healthcare professionals, and the growing number of diabetes patients are intensifying the strain on public health systems. Crowd profile, centered on user needs, is seen as a critical technique for empowering patients in proactive management and improving public health cost-effectiveness. This study reviews the current application of crowd profile in diabetes management, highlighting the its potential to improve diabetes management by providing personalized, data-driven support to patients and medical professions. By integrating big data, artificial intelligence, and other digital technologies, crowd profile aims to analyze patients' behavior patterns, health history, and lifestyle habits, thereby enhancing the flexibility and effectiveness of diabetes management. In addition, the application of crowd profile in digital diabetes consultations has brought more intelligent and personalized solutions to diabetes management. Thus, diabetes patients can receive more accurate medical services and improved health management guidance, enhancing the usage frequency and duration of health management software.

However, as data privacy concerns rise and patient needs evolve, future research will require more sophisticated and dynamic crowd profiling models. Advances in crowd profile technique must address data privacy and security to build patient trust and engagement. Furthermore, future crowd profile should integrate multidimensional health data, such as genomics and wearable device monitoring data, to dynamically update patients' health information and achieve more precise health management.

Acknowledgments

This paper is supported by Scientific and Technological Major Special Project of Fujian Provincial Health Commission (No.2021ZD01004).

References

[1] Mingzhen Li, Zhang Bing, Guo Lichuan, et al. Portrait for Type 2 Diabetes with Goal-

Achieved HbA1c Using Digital Diabetes Care Model: A Real-World 12-Month Study from China. Patient preference and adherence, 2023, 172227-2235.

[2] Jinli Liu, Liu Min, Chai Zhonglin, et al. Projected Rapid Growth in Diabetes Disease Burden and Economic Burden in China: A Spatio-temporal Study from 2020 to 2030. The Lancet Regional Health - Western Pacific, 2023, 33(100700).

[3] George Moschonis, Siopis George, Jung Jenny, et al. Effectiveness, Reach, Uptake, and Feasibility of Digital Health Interventions for Adults with Type 2 Diabetes: A Systematic Review and Meta-analysis of Randomised Controlled Trials. The Lancet Digital Health, 2023, 5(3): e125-e143.

[4] Sebastian Stevens, Gallagher Susan, Andrews Tim, et al. The Effectiveness of Digital Health Technologies for Patients with Diabetes Mellitus: A Systematic Review. Frontiers in Clinical Diabetes and Healthcare, 2022, 3.

[5] Iris-Ten Klooster, Image Author-Orcid, Wentzel Jobke, et al. Personas for Better Targeted eHealth Technologies: User-Centered Design Approach. JMIR Hum Factors, 2022, 9(1): E24172.

[6] Sara-Laureen Bartels, Taygar Afra-S, Johnsson Sophie-I, et al. Using Personas in the Development of eHealth Interventions for Chronic Pain: A Scoping Review and Narrative Synthesis. Internet Interventions, 2023, 32100619.

[7] Z Guan, Li H, Liu R, et al. Artificial Intelligence in Diabetes Management: Advancements, Opportunities, and Challenges. Cell Rep Med, 2023, 4(10): 101213.

[8] Shaogang Gong, Loy Chen-Change, Chen Ke, et al. Crowd Counting and Profiling: Methodology and Evaluation. New York, NY: Springer New York, 2013: 347-382.

[9] Muhammad-Exell Febrian, Ferdinan Fransiskus-Xaverius, Sendani Gustian-Paul, et al. Diabetes Prediction Using Supervised Machine Learning. Procedia Computer Science, 2023, 21621-30.

[10] Rashi Rastogi, Bansal Mamta. Diabetes prediction Model Using Data Mining Techniques. Measurement: Sensors, 2023, 25100605.

[11] G Fico, Martinez-Millana A, Leuteritz J-P, et al. User Centered Design to Improve Information Exchange in Diabetes Care Through eHealth: Results from a Small Scale Exploratory Study. J Med Syst, 2019, 44(1): 2.

[12] Mi-Kyoung Cho, Kim Mi-Young. Self-Management Nursing Intervention for Controlling Glucose among Diabetes: A Systematic Review and Meta-Analysis. International Journal of Environmental Research and Public Health, 2021, 18(23): 12750.

[13] Chollette-C Olisah, Smith Lyndon, Smith Melvyn. Diabetes Mellitus Prediction and Diagnosis from a Data Preprocessing and Machine Learning Perspective. Computer Methods and Programs in Biomedicine, 2022, 220106773.

[14] Bin Sheng, Guan Zhouyu, Lim Lee-Ling, et al. Large Language Models for Diabetes Care: Potentials and Prospects. Science Bulletin, 2024, 69(5): 583-588.

[15] Rosanna O Ciani, Petracca Francesco, Svae Liv, et al. Which Behaviour Change Techniques Work Best for Diabetes Self-management Mobile Apps? Results from a Systematic Review and Meta-analysis of Randomised Controlled Trials. EBioMedicine, 2024, 103105091.

[16] N Galliford, Yin K, Blandford A, et al. Patient Work Personas of Type 2 Diabetes-A Data-Driven Approach to Persona Development and Validation. Front Digit Health, 2022, 4838651.

[17] Michelle-L Litchman, Walker Heather-R, Fitzgerald Caroline, et al. Patient-Driven Diabetes Technologies: Sentiment and Personas of the #WeAreNotWaiting and #OpenAPS Movements. Journal of Diabetes Science and Technology, 2020, 14(6): 990-999.

[18] A-K Bohm, Jensen M-L, Sorensen M-R, et al. Real-World Evidence of User Engagement with Mobile Health for Diabetes Management: Longitudinal Observational Study. JMIR Mhealth Uhealth, 2020, 8(11): e22212.

[19] Stephen-R Ali, Dobbs Thomas-D, Hutchings Hayley-A, et al. Using ChatGPT to Write Patient Clinic Letters. The Lancet Digital Health, 2023, 5(4): e179-e181.

[20] S Amagai, Pila S, Kaat A-J, et al. Challenges in Participant Engagement and

Retention Using Mobile Health Apps: Literature Review. J Med Internet Res, 2022, 24(4): e35120.
[21] Signe-Marie Cleveland, Haddara Moutaz. Internet of Things for Diabetics: Identifying Adoption Issues. Internet of Things, 2023, 22100798.

