Exploring the Potential in Utilising Smartphones to Aid in the Treatment and Management of Inflammatory Bowel Disease

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***Abstract*—Inflammatory Bowel Disease (IBD) is an incurable chronic illness needing ongoing outpatient treatment and support. This paper identifies a number of challenges faced by the various stakeholders of the illness, much of which is rooted in a need for more information on how lifestyle, in a broad sense, impacts the disease and explores the potential to utilise smartphones to address some of the identified concerns. Mobile Health (m-Health) is a growing field, with smartphones being widely adopted across the healthcare arena. We identify an appetite among IBD patients for a smartphone solution which aids in the self-management of the disease and assists in communicating their needs to their respective clinical teams. Several examples of how smartphones have been utilised to aid in the treatment and management of chronic diseases, such as diabetes and some mental health conditions, which share similar challenges to that of IBD were explored, giving precedent as to how the technology could be utilised in the context of IBD. From the evidence at hand, we propose that smartphones provide a promising opportunity to develop a tool to aid in the treatment and management of IBD and outline the scope of future research into the field.**

Keywords—Inflammatory Bowel Disease; IBD; Outpatient Management; Self-Management; m-Health; Smartphones; Chronic Disease

I. INTRODUCTION

The burden of long-term chronic disease, also known as (AKA) Noncommunicable disease (NCD) [1], is one of the biggest challenges health systems globally will face during the twenty-first century [2], [3]. By definition a chronic illness is one which has no cure but can be managed with the use of either medication, clinical therapy or both [2], [4]. The United Kingdom (UK) has recognised the serious threat of long-term chronic disease, implementing government policy across all member states in order to deal with the problem over the coming decades [4]–[7]. The World Health Organisation has warned that global rates of long term afflictions are predicted to rise, with projections up to 2030 firmly set on an upward trajectory, and that "the adverse human, social and economic consequences" of chronic diseases will negatively impact all "societies and economies" [3, p. 1].

Technology, even in its most basic form for modern standards, plays a vital role in the management of chronic illnesses [3]. The prominence of smartphones globally [8], [9], the UK not withstanding [10], has facilitated the rise of new technological opportunities to develop assistive tools for the benefit of various fields in healthcare [11], [12]. This paper considers the prospect of utilising mobile health (m-Health), e.g. smartphones and tablets etc., to address some of the challenges faced in the treatment and management of one particular chronic illness, Inflammatory Bowel Disease (IBD). First, an overview of the disease will be presented, along with some of the challenges the various stakeholders face in managing the illness. Second, there will be a general exploration of how smartphones can and have been used to help with patient care. Finally, there will be a discussion on how m-Health can be applied within the context of IBD and the prospect of future research into this field.

II. OVERVIEW OF INFLAMMATORY BOWEL DISEASE

A. Epidemiology and Cost

Inflammatory bowel disease (IBD) is a hypernym for a class of chronic, often relapsing, lifelong inflammatory conditions, which affects one's gastrointestinal tract [13]–[15]. The two main derivatives of IBD include Crohn's disease (CD) and Ulcerative Colitis (UC) [13]–[19], where CD affects the entire digestive system from mouth to anus, i.e. any part of the gastrointestinal tract, while UC is confined to the colon [15], [17], [19], [20]. Little is known or understood about the pathogenesis of IBD [13], [19] and while UC can be cured, in a manner of speaking, through a total colectomy there is no known cure for CD [19].

Initial diagnosis of IBD mainly occurs in patients between the ages of 15 and 30 [18], [21], with the highest instances of the disease occurring in the industrialised west; mainly North America and Northern Europe [21]. The disease, however, is gaining traction around the world, where rates of IBD in Southern Europe, Asia and developing countries are steadily increasing [16], [18]. IBD, in the context of UC and CD, affects an estimated 300,000 people in the UK [22], 1.3 million in the United States of America (USA) [23] and 3 million people across Europe [24].The illness has long been considered a "western disease" [25] but with a steady increase in global incidents it is fast becoming an international problem [21], [26], [27]. A burden which will, invariably, place a strain on

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each region's respective healthcare system and economy as a whole [27]. It is estimated that treatment of IBD in Europe will result in a direct annual healthcare cost of 4.6 to 5.6 billion Euros per year [24].

The disease is a matter of concern for the UK where, according to the National Health Service (NHS) [22], approximately 1 in 250 people live with the illness. It is estimated that there are 146,000 people suffering with UC and 115,000 people suffering with CD in the UK [22]. Ghosh and Premchand [28] estimate the annual cost to the NHS for treating each UC patient is £3084; £1693 for patients in remission, £2903 for those experiencing a mild to moderate relapse and £10,760 for patients with severe symptoms. In turn, for each CD patients the annual cost is estimated at around £6156; £1800 for patients in remission and £10,513 for those experiencing a relapse [28]. The stark increase in the cost of helping those suffering from a relapse gives credence to the need to induce and maintain remission.

B. How IBD affects patients

Those who are most inconvenienced by the disease are of course the patients themselves, whose quality of life is at risk of serious impairment as a result of the illness [27]. Thomas [29, p. 19] explains, as is the case with many chronic conditions, "*a diagnosis of IBD is not a death sentence, but it can often be a life sentence,"* which, in conjunction with the physical implications, is a burden that will force change to the "personal, social and emotional lives" of patients and, potentially, their family. People diagnosed with IBD can be burdened with a large variety of symptoms including diarrhoea and, often, an increased urgency to go to the toilet where bowel movements can often be bloody [14], [18], [19], [30], vomiting [19], abdominal cramps and rectal pain of varying severity [14], [19], [30], a loss of appetite and weight loss [14], fatigue [14], [19], [30], [31], fever [14], [18], [19], anaemia [32]–[34] and a cacophony of extraintestinal manifestations (EIM) including arthritis, swollen joints, inflammation of the spine, skin lesions or inflamed eyes [30]–[33], [35], fistulas and abscesses [35]. Due to the nature of the disease and the manner by which it affects the gastrointestinal tract, patients are often at risk of malnutrition [19], [35], [36].

In addition to the physical burden of the disease, IBD can have a severe impact on the mental health and wellbeing of patients afflicted with the illness [14], [30], [31]. A recurring theme within the literature is that people often want to regain a sense of "control", a privilege that is easily threatened by the prevalence of the illness [14], [30], [31]. Furthermore, IBD patients often feel isolated, lonely, alienated, ashamed and embarrassed and therefore risk suffering from anxiety, depression and low self-esteem [14], [31].

C. Managing the Disease

From the point of diagnosis, those afflicted with IBD require lifelong outpatient support to help manage their condition [19], [32]. Medical practitioners specialising in Gastroenterology, including but not limited to Gastroenterologist [37], specialist IBD nurses [38] and dieticians [39], provide clinical support throughout various stages of the illness. The primary objective of clinical treatment is to reduce the symptoms as quickly as possible and to bring on remission or maintain control of the disease so as to allow for a comfortable quality of life [18], [19].

Consequently, in tandem with receiving clinical support, self-management of the disease inevitably becomes a priority for IBD patients, who often must implement a number of lifestyle changes in order to control the disease including managing medication, dietary changes, managing the exacerbation of symptoms and dealing with the psychological and social impact of IBD [30], [40].

Dietary changes are an important part of patient self-management, with evidence suggesting that diet can have an impact on the status and symptoms of the disease [41], [42]. However, there is not enough evidence to suggest any particular diet can help or relieve symptoms, posing a challenge for both patient and clinicians alike [19], [34], [36], [43].

The management of IBD presents a challenge to all stakeholders, the root of which stems from a necessity for information. For patients, there is a strong desire to restore some modicum of control over their life [14], [30], [31], [44], however little is known about what is the optimum means of self-management [30]. Furthermore, clinicians, patients and researchers alike need far greater information on how diet impacts the status of the condition [19], [34], [36], [43].

III. Smartphones in Healthcare

Smartphones have become a prominent part of everyday life, the technology was quickly adopted by consumers and it is estimated that 66% of UK adults own a smartphone [10]. According to Boxall [8], citing a report by telecoms company Ericsson [9], in 2014 there was an estimated 2.6 billion smartphone users worldwide with global estimates set to reach nearly 6.1 billion by 2020. Due to their promising potential smartphones have been adopted as a tool within various fields of healthcare [12].

In a review of healthcare apps, Mosa et al. [12] discovered that there were a diverse number of applications targeting a number of stakeholders including healthcare professionals, medical or nursing students and patients. The study was able to further compartmentalise the various applications based on their primary focus, categorising them as disease diagnostic tools, drug reference applications, medical calculators, literature search applications, applications for clinical communication, hospital information systems, medical training applications, general healthcare applications and applications for patients to assist in the management of various illnesses, a number of which are chronic diseases [12]. The authors [12, p. 14] stated that smartphones "will enable healthcare professionals to use the applications in a more meaningful way for better patient care", concluding that the applications reviewed were designed as supplementary tools to help healthcare professionals, not replace them [12].

Smartphones, as research has indicated, offer great potential to help patients and healthcare professionals manage chronic illness [11], [45]. So as to better understand how smartphones may be utilised to address some of the challenges faced in managing IBD the following section will briefly revisit the problems touched upon, explore research relevant to

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the field of m-health in relation to IBD and that which focuses on the application of smartphones in the context of other chronic diseases facing similar obstacles, reflecting on how smartphones can be employed to assist in the context of IBD.

A review of the IBD literature reveal a number of challenges faced by the various stakeholders dealing with the disease, many of which stem from a need for more information on how lifestyle, in a broad sense, impacts the disease [19], [30], [34], [36], [43]. Researchers have called for more data to understand what is the optimum diet for maintaining remission [19], [34], [36], [43] and the best practices for outpatient self-management [30]. A study by Khan et al. [44] found that patients want an app that informs their medical team on their status between check-ups and help them keep track of their symptoms and medication adherence. This would also help to give their consultants a better understanding of their situation outside of the clinic [44].

Smartphones present great potential in helping patients and doctors manage IBD, yet there has been little research into the field. There are a number of commercially available IBD related apps for the Android and iOS mobile operating systems (OS) [46]. Con and De Cruz [46] conducted a study to assess the efficacy and validity of commercially available mobile phone apps, available in Australia, developed to assist patients in the self-management of IBD. The researchers screened 238 apps on both the Android and iOS OS out of which they analysed 26 which were deemed relevant to the task of patient IBD self-management. Apps which, for example, were not focused on IBD, not in English, inaccessible without permission and not targeted towards patients were excluded. The authors concluded that most failed to cover many of the evidence based requirements stated in international guidelines and none of the apps provide decision support for the patient's self-management of IBD [46].

Boulos et al. [11] explored the opportunity for smartphones to assist in the treatment and management of chronic illness, highlighting the technology's strength in collecting outpatient data. The authors presented a case study of one particular app, eCAALYX, built as a remote monitoring tool for elderly patients with multiple chronic illnesses and conclude that smartphones are a useful tool for clinicians to monitor and diagnose patients from a distance [11].

Expanding on the notion of outpatient monitoring, Reid et al. [47] demonstrated how smartphones could help Paediatricians monitor the mental health wellbeing and symptoms of their adolescent patients. The qualitative study was run over 2 to 4 weeks and received positive feedback from patients and their doctors, where 88% of the doctors reported gaining a better insight into their patients' activities and likewise, patients felt better understood [47]. Their work illustrates the prospect for smartphones to improve communication between patients and clinical staff, facilitating a greater understanding of any given patient's situation, a requirement alluded to by the work of Khan et al. [44].

The self-management of one's condition is an important necessity for those afflicted with a chronic disease such as IBD [30], [40], a concept no less significant for illnesses such as Type 2 Diabetes which require patients to take control of their own healthcare [48], [49]. Quin et al [45] demonstrated how a mobile and web based application, Maximal Treatment, could be used to help patients with class 2 diabetes manage their condition. The research was conducted using 163 patients and showed that smartphones could be used to help patients with diabetes substantially reduce their levels of glycated haemoglobin over a one year period [45].

Smartphones have shown promise in the field of mental health [47], [50], an area of significant importance for IBD patients [14]. Luxton et al. [50] assert that smartphones are of great potential as a tool for behavioural healthcare within the context of clinical practice, mental health education and access to clinical information. The authors allude to the existence of a number of healthcare apps focused on mental health and suggest that there is scope to expand into a number of niche fields, which could potentially support the advancement of clinical care [50].

IV. Discussion and Conclusion

The global ascent of long-term chronic disease poses a serious challenge to all nations, the social and economic ramifications of which has spurred the World Health Organisations to call on all societies to treat the situation as a matter of urgency [3]. The UK has recognised the continued growth and implications of chronic illnesses and has therefore implemented policy to deal with the problem across all of its member states [4]–[7].

IBD is an incurable chronic condition which was traditionally associated with the industrialised west, North America and Northern Europe [21], however global incidents of the disease continues to rise, elevating the issue to that of an international problem [16], [18]. IBD patients require ongoing treatment and care [19], [32] involving a number of clinical specialists [37]–[39]. The nature of the disease force those afflicted to implement a number of lifestyle changes and a self-management regime must, invariably, be adopted in the hopes of controlling the disease [30], [40]. The management of IBD presents a number of challenges for the various stakeholders, concerning issues such as diet [19], [34], [36], [43], self-management best practices and support [30] and better communication between patients and their medical team [44].

Smartphones have been successfully adopted as a tool within healthcare [12] and some progress has been made in utilising the technology to support the treatment of chronic disease [11], [12]. In the context of the latter, smartphones have the capacity to provide additional support such as but not limited to, monitoring and gathering data on outpatients so as to assist clinical staff in better understanding their patients situation [11], [47] and helping patients better self-manage their condition [45].

The potential for smartphones to help in the treatment and management of IBD has had little exploration. A number of commercial smartphone apps targeting IBD do exist, however many fail to satisfy evidence based requirements and none provide decision support to aid patients self-manage the disease [46]. Research [44] has found that there is an appetite for the technology to be utilised as a tool to assist patients self-manage their condition, track the status of their illness and the

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progress of their treatment and better communicate their situation to their clinical support staff [44].

The treatment of chronic disease is a complex issue, one which is subject to a variety of factors which may impact a patient's health. The challenges subject to the treatment and management of IBD, identified in this paper, are also similarly encountered within the domain of other chronic illnesses; Diabetes [49], Heart disease [51] and Hypertension [52], for example, all require the patient to undergo long term outpatient care and self-manage their condition, the latter of which often necessitates an alteration to their lifestyle and diet in addition to the adoption of a prescribed medication regime. So as to better understand how the aforementioned challenges may be addressed, several studies [11], [45], [47], [50] were explored, each of which demonstrate how they tackled some of the concerns, touched upon, within the context of other chronic conditions. The works of Boulos et al. [11] and Reid et al. [47] show how m-health can address the challenge of monitoring and collecting data on outpatients to better support clinical treatment and research. Quin et al [45] gave insight into how smartphones could be utilised to help patients with diabetes self-manage their condition, while Luxton et al. [50] explored the potential for smartphones to serve as a useful tool in the field of mental health.

As demonstrated, the successful adoption of smartphones as a tool in other areas of healthcare, such as diabetes and mental health conditions, presents an opportunity to investigate how the technology could be utilised as a tool to support the outpatient treatment and management of IBD. Despite the progress already made, there is still considerable scope for more research into how m-health can be used to support the treatment of chronic disease.

IBD, a disease which presents a cacophony of symptoms, requires a variety of treatments and were the successful management of the illness is intrinsically linked to one's lifestyle and diet, offers an opportunity to push the boundary of m-health and test the effectiveness of utilising mobile technology to aid with the treatment of complex chronic conditions. The successful application of m-health to the field of IBD would set a president for dealing with a variety of chronic diseases, many of which share common characteristics and face similar challenges.

V. Final Remarks and Future Research

This paper has established that IBD, like many chronic diseases, is a matter of concern not only in the UK but around the world as well. There are several challenges stakeholders of the disease face when treating and managing the condition, many of which are rooted in the need for more data and better communication of information between the various stakeholders. Smartphones have been used to address similar challenges faced in treating and managing other chronic illnesses and gives some understanding into how the technology could be used to address some of the issues faced within the context of IBD.

Work is underway to tackle some of the challenges presented in this paper with research being conducted, by us the authors, to address the following question:

- How can smartphones be utilised to assist patients in the self-management of IBD, collect outpatient data for the benefit of clinical staff and collect data that will help researchers better understand the disease?

The project aims to develop a computational system using mobile technology to aid the various stakeholders involved in the treatment and management of IBD, while concurrently collecting vital data from outpatients to further assist in the progress of biomedical and nutritional research. One key area of interest is the prospect of using the technology to gain further insight into the relationship between lifestyle habits, particularly diet, and the severity of symptoms. This will be achieved by developing an Android smartphone application that will help IBD patients monitor their day to day symptoms, diet, medication adherence, and mental health, providing informational support where necessary. Subsequently, two separate web portals will be prototyped, one to present collected data to clinical staff charged with the patient's care and one to present anonymised data for the benefit of IBD researchers.

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