Bibliometric analysis of interventional literature on mobile health: The most highly cited articles

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Article Info

Article type:
Review

Article History:

Received: 2020-12-04
Accepted: 2021-02-06
Published: 2021-03-08

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Keywords:

Telemedicine
Mobile Health
Top Cited
Publications
Bibliometric

ABSTRACT

Introduction: Advances in mobile health have led to numerous relevant studies in diagnosis, treatment, and controlling of various diseases. One of the criteria indicating the quality of the previously published studies is the number of citations. Therefore, investigating the features of highly cited articles and identifying the most frequently used mobile technological interventions can affect future research ideas. This study aimed at identifying 100 highly cited interventional studies on mobile health, type of used mobile technologies, and effect of these technologies in various diseases in top-cited articles.

Material and Methods: The database employed in this study was the Web of Science, which without limitations was analysed in April 2020 to identify 100 highly cited interventional studies in the field of mobile health. The identified studies were classified based on the number of citations, year of publication, country of the first author, type of disease, and use of mobile technology.

Results: A great majority of the studies in the field of interventional mobile health focused on obesity (n=18), addiction (n=15), diabetes (n=13) and mental health disorders (n=12), respectively. Many studies employed mobile technologies to promote lifestyle (weight loss and increased physical activity) (n=20), disease controls (n=20), and treatment adherence (n=18). The mean number of citations per study was 146±97. The most cited study was in the category of viral disease treatment adherence (n=703), and the most cited articles were published in 2012.

Conclusion: Among the reviewed 100 studies, many of the interventional studies regarding mobile health focused on obesity, addiction, diabetes and mental health disorders. Promotion of lifestyle, disease controls, and treatment adherence were effects of mobile technologies in top-cited articles. Text messaging service was used as intervention in most of the studies. Thus, future studies may focus on the use of various mobile applications on different diseases' prevention, control, and treatment.

Cite this paper as:

Ameri A, Salmanizadeh F, Bahaadinbeigy K. Bibliometric Analysis of Interventional Literature on Mobile Health: The Most Highly Cited Articles. Front Health Inform. 2021; 10: 66. DOI: [10.30699/fhi.v10i1.262](https://doi.org/10.30699/fhi.v10i1.262)

INTRODUCTION

The emergence of mobile devices in the 1990s allowed physicians easier access to medical records, test results, medical imaging and pharmaceutical information [1]. Moreover, through using this technology, patients can be diagnosed and monitored at any time and place via a mobile telephone [1]. Therefore, the use of this technology in the field of health service has created the term 'mobile health'

('M-health'). Mobile health can be defined as the use of mobile technologies to provide each individual with health care services at any time and place by removing spatial and time limitations [2]. A great number of health care problems could be resolved by using mobile health to access health care, make decisions, and manage chronic and critical conditions [2].

Mobile health uses a combination of mobile

telephone potential and other mobile technologies, such as telephone calls, short message service (SMS) and mobile applications, to provide health, medical and educational services [1]. The various capabilities of mobile health in increasing remote monitoring of patients have laid the ground for numerous investments [3]. According to Statista's report, by 2021, the global mobile health market will grow to nearly \$100 billion [4]. This provides many opportunities to prepare efficient mobile health solutions. As a result, advances in the implementation of mobile health techniques have been concurrent with numerous studies investigating the diverse capabilities of mobile health for disease prevention, control and treatment [2, 5]. One of the indices of quality assessment of these previously published articles is their number of citations. Citation occurs when one scientific article uses another as a reference. The more times an article is cited, the more valuable is that article [6].

Highly cited articles can be reviewed with the purpose of identifying the type and place of research, showing the progress of texts over time, determining the most cited areas and countries, helping researchers and students identify new areas to work on, identifying the most contributing authors in this field and determining the organizational affiliation of the authors [7–10]. Recently, ISI introduced the newest journal citation system, Science Citation Index® (SCI) Expanded, which is one of the databases available in the Web of Science (WOS) portal. Through using the citation data retrieved from WOS databases, researchers have identified and analysed highly cited articles in different areas, such as medical informatics, telemedicine and other clinical sciences, including psychiatry, ophthalmology, anaesthesia, orthopaedics, rehabilitation and delivery [11–18]. In a bibliometric study, Sweileh et al. reviewed all published studies on mobile health between 2006 and 2016 [19]. However, as far as the authors of this article are aware, no study has yet reviewed 100 highly cited articles on mobile health interventions. Therefore, reviewing the features of highly cited articles on mobile health interventions, and determining the most widely used mobile technology interventions, as well as their capabilities and applicability, can affect future research ideas and real use of these technologies in various diseases and healthcare services. This work will also be useful to researchers and policy makers. Therefore, the present study aimed to identify 100 highly cited interventional articles in the field of mobile health and to address the following questions:

What are type of used mobile technologies in 100 highly cited interventional articles?

What are impact of mobile technology interventions in various diseases in top-cited articles?

MATERIAL AND METHODS

The present study is a bibliometric analysis of the most highly cited interventional articles on mobile health, using data obtained from the WOS in August 2020. The citation counts from resources such as Google Scholar, Scopus and WOS vary [20]. We chose WOS because we found it was the database providing the highest scientific quality. WOS has been shown to be the most robust scientific database resource for medicine [21]. Mobile health (M-health) is the term used to designate applications that support medicine and health services through mobile devices [22]. In this study, the search was conducted without any time limit in WOS (all years = 1900–2020). The articles were searched by word combination related to mobile health. The keywords were searched based on TS (topic) field. In WOS, the topic fields contain title, abstract, author, keywords and keywords plus® [23]:

TS = ("mobile health" OR "M health" OR "mobile application" OR "smartphone" OR "Mobile technology" OR "Mobile communication technology" OR "Text messag*")

After searching the database, the extracted articles were sorted according to the number of citations (times cited).

Inclusion criteria for articles

The inclusion criteria were as follows. (1) The reviewed studies focused on mobile health interventions and other mobile technologies in healthcare. (2) We included interventional studies (e.g., randomised clinical trial, quasi-experimental studies, case studies, experimental pilot studies and quasi-experimental pilot studies) and excluded descriptive and qualitative studies. (3) The research articles had to be original articles, not review articles, conference presentations, and letters to the editor, short communications, reviews or case reports.

Selection, data collection and analysis

After performing the search, 26,834 articles were retrieved. The title and abstract of each article were studied and the articles that met all inclusion criteria were included. Based on previous studies [11, 13–16], we also selected 100 highly cited articles. To find the 100 top cited articles related to the purpose of the study, we evaluated 489 highly cited articles on the WOS database, and 100 cited articles that met all the inclusion criteria were included in Endnote X8.0.1. The bibliometric information and full text of the final articles were then reviewed. Each article was examined based on attributes such as journal name, journal impact factor, year of publication, geographic origin, total number of citations, and type of disease and performance of mobile technology. The information extracted from these articles was

entered into Microsoft Excel 2018. The mean number of citations per article and the range of citations were calculated using SPSS 24.

RESULTS

In this study, to select 100 highly cited papers related to the purpose of the study, 484 highly cited articles were extracted from the WOS database. Then 100 highly cited articles related to the aims of the study were categorised by disease and the type of mobile technology employed in that study (Table 1). In the disease category, studies were divided according to the type of disease that the participants had and the

affected body part. In this category, the greatest number of intervention articles in the field of health addressed obesity (n=18), addiction (n=15), diabetes (n=13) and mental health disorders (n=12), respectively. Studies in which the patients had multiple chronic diseases were categorised as 'general medicine'. Studies that used mobile technology interventions to lose weight and increase physical activity were categorised as 'impact on lifestyle'. Thus, in terms of the function of mobile technologies, most studies used this technology to enhance lifestyle (n=20), control diseases (n=20) and encourage adherence to treatment (n=18) (Table 1).

Table 1: Classification of 100 highly cited interventional studies on mobile health by type of disease and performance of mobile technology

Disease Categories	Number	Functionality Categories	Number
Addiction	15	Alcohol addiction quitting	3
Cancer	3	Detecting diseases	5
Diabetes	13	Disease controls	20
ENT diseases	1	Attendance/ Appointment reminders	7
Eye diseases	1	Knowledge improvement	2
Gynecology/obstetrics	6	Self-monitoring	9
Heart diseases	7	Cigarette smoking quitting	12
Infectious diseases	3	Treatment adherence	18
Liver diseases	2	Vaccination reminders	4
Mental health disorders	12	Impact on lifestyle	20
Neurological disorders	1	Total	100
Obesity	18		
Respiratory diseases	4		
Viral diseases	8		
General medicine	5		
Skin care	1		
Total	100		

Table 2 presents the names of articles, number of citations and category of each article. The number of citations to the articles ranged between 84 and 740. The mean number of citations per article was 153 ± 100 . The most cited article was in the category of adherence to treatment and viral diseases [24] (Table 2).

Table 3 displays the name of the journal and its impact factor. The majority of articles were published in the Journal of Medical Internet Research (n = 9), while the most cited article in this study was published in 2010 in Lancet Journal [24]. The impact factor of the journals was between 0.954 and 59.102,

and the highest impact factor belonged to Lancet Journal.

Table 4 presents the countries of the first authors of the 100 most cited articles relevant to the objectives of the present study. The first authors of these articles were based in the United States (n=45), Australia (n=13), England (n=11) and New Zealand (n=6), respectively (Table 4).

This study covered 100 highly cited interventional studies on mobile health between 2002 and 2016, and the highest number of citations pertinent to the goal of this research was published in 2012 (Fig 1).

Table 2: One hundred highly cited interventional studies on mobile health

Rank	Citations	Author(s)/ year	Disease Categories	Functionality Categories
1	740	Lester et al., 2010 [24]	Viral diseases	Treatment adherence
2	547	Pop-Eleches et al., 2011 [25]	Viral diseases	Treatment adherence
3	434	Rodgers et al., 2005 [26]	Addiction	Cigarette smoking quitting
4	430	Free et al., 2011 [27]	Addiction	Cigarette smoking quitting

Rank	Citations	Author(s)/ year	Disease Categories	Functionality Categories
5	388	Patrick et al., 2009 [28]	Obesity	Impact on lifestyle
6	345	Franklin et al., 2006 [29]	Diabetes	Disease controls
7	309	Carter et al., 2013 [30]	Obesity	Impact on lifestyle
8	269	Gustafson et al., 2014 [31]	Addiction	Alcohol addiction quitting
9	267	Quinn et al., 2011 [32]	Diabetes	Self-monitoring
10	256	Burns et al., 2011 [33]	Mental health disorders	Disease controls
11	248	Chow et al., 2015 [34]	Heart diseases	Disease controls
12	212	Zurovac et al., 2011 [35]	Infectious diseases	Treatment adherence
13	210	Laksanasopin et al., 2015 [36]	Infectious diseases	Detecting diseases
14	206	Stockwell et al., 2012 [37]	Respiratory diseases	Vaccination reminders
15	200	Napolitano et al., 2013 [38]	Obesity	Impact on lifestyle
16	199	Jakicic et al., 2016 [39]	Obesity	Impact on lifestyle
17	197	Ben-Zeev et al., 2014 [40]	Mental health disorders	Disease controls
18	191	Wolf et al., 2013 [41]	Cancer	Detecting diseases
19	190	Obermayer et al., 2004 [42]	Addiction	Cigarette smoking quitting
20	182	Strandbygaard et al., 2010 [43]	Respiratory diseases	Treatment adherence
21	182	Leong et al., 2006 [44]	General medicine	Attendance/appointment reminders
22	174	Hanauer et al., 2009 [45]	Diabetes	Disease controls
23	173	Varnfield et al., 2014 [46]	Heart diseases	Disease controls
24	170	Granhölm et al., 2012 [47]	Mental health disorders	Treatment adherence
25	168	Depp et al., 2010 [48]	Mental health disorders	Self-monitoring
26	167	Haapala et al., 2009 [49]	Obesity	Impact on lifestyle
27	163	Armstrong et al., 2009 [50]	Skin care	Treatment adherence
28	161	Petrie et al., 2012 [51]	Respiratory diseases	Treatment adherence
29	161	Wang et al., 2011 [52]	Cancer	Detecting diseases
30	157	Borland et al., 2013 [53]	Addiction	Cigarette smoking quitting
31	153	King et al., 2013 [54]	Obesity	Impact on lifestyle
32	150	Watts et al., 2013 [55]	Mental health disorders	Disease controls
33	149	Downer et al., 2005 [56]	General medicine	Attendance/appointment reminders
34	140	Chen et al., 2008 [57]	General medicine	Attendance/appointment reminders
35	140	Kirwan et al., 2013 [58]	Diabetes	Self-monitoring
36	139	Bricker et al., 2014 [59]	Addiction	Cigarette smoking quitting
37	138	Laing et al., 2014 [60]	Obesity	Impact on lifestyle
38	137	Miloh et al., 2009 [61]	Liver diseases	Treatment adherence
39	135	McManus et al., 2013 [62]	Heart diseases	Detecting diseases
40	133	Kharbanda et al., 2011 [63]	Viral diseases	Vaccination reminders
41	130	Shapiro et al., 2008 [64]	Obesity	Self-monitoring
42	129	Charpentier et al., 2011 [65]	Diabetes	Disease controls
43	128	Gerber et al., 2009 [66]	Obesity	Impact on lifestyle
44	124	Spring et al., 2012 [67]	Obesity	Impact on lifestyle
45	123	Vervloet et al., 2012 [68]	Diabetes	Treatment adherence
46	123	Mbuagbaw et al., 2012 [69]	Viral diseases	Treatment adherence
47	122	Hardy et al., 2011 [70]	Viral diseases	Treatment adherence
48	121	Suffoletto et al., 2012 [71]	Addiction	Alcohol addiction quitting
49	119	Arora et al., 2015 [72]	Neurological disorders	Detecting diseases
50	117	Koshy et al., 2008 [73]	Eye diseases	Attendance/appointment reminders
51	116	Dowshen et al., 2012 [74]	Viral diseases	Treatment adherence
52	115	Haines et al., 2013 [75]	Obesity	Impact on lifestyle
53	113	Rizvi et al., 2011 [76]	Mental health disorders	Disease controls
54	113	Glynn et al., 2014 [77]	Obesity	Impact on lifestyle
55	112	Stockwell et al., 2012 [78]	Infectious diseases	Vaccination reminders
56	112	Proudfoot et al., 2013 [79]	Mental health disorders	Disease controls
57	111	da Costa et al., 2012 [80]	Viral diseases	Treatment adherence
58	110	Hou et al., 2010 [81]	Gynecology/obstetrics	Treatment adherence
59	109	Bopp et al., 2010 [82]	Mental health disorders	Disease controls
60	108	Altice et al., 2007 [83]	Viral diseases	Treatment adherence
61	106	Ryan et al., 2012 [84]	Respiratory diseases	Self-monitoring
62	105	Franklin et al., 2008 [85]	Diabetes	Disease controls
63	105	Spring et al., 2013 [86]	Obesity	Impact on lifestyle
64	104	Riley et al., 2008 [87]	Addiction	Cigarette smoking quitting
65	103	Kirwan et al., 2012 [88]	General medicine	Impact on lifestyle
66	103	Istepanian et al., 2009 [89]	Diabetes	Disease controls
67	103	Whittaker et al., 2008 [90]	Addiction	Cigarette smoking quitting
68	103	Ferrer-Roca et al., 2004 [91]	Diabetes	Disease controls
69	103	Baker et al., 2014 [92]	Cancer	Treatment adherence
70	101	Wang et al., 2015 [93]	Obesity	Impact on lifestyle
71	99	Gómez et al., 2002 [94]	Diabetes	Disease controls

Rank	Citations	Author(s)/ year	Disease Categories	Functionality Categories
72	99	Lund et al., 2014 [95]	Gynecology/obstetrics	Attendance/ Appointment reminders
73	99	Bobrow et al., 2016 [96]	Heart diseases	Treatment adherence
74	98	Ly et al., 2014 [97]	Mental health disorders	Self-monitoring
75	98	Worringham et al., 2011 [98]	Heart diseases	Disease controls
76	97	Lim et al., 2012 [99]	Gynecology/obstetrics	Knowledge improvement
77	97	Vilella et al., 2004 [100]	Liver diseases	Vaccination reminders
78	97	Smith et al., 2014 [101]	Obesity	Impact on lifestyle
79	97	Logan et al., 2012 [102]	Heart diseases	Disease controls
80	96	Maddison et al., 2015 [103]	Heart diseases	Impact on lifestyle
81	96	Woolford et al., 2010 [104]	Obesity	Impact on lifestyle
82	95	Buller et al., 2014 [105]	Addiction	Cigarette smoking quitting
83	94	Shapiro et al., 2012 [106]	Obesity	Impact on lifestyle
84	93	Whittaker et al., 2011 [107]	Addiction	Cigarette smoking quitting
85	93	Hebden et al., 2014 [108]	Obesity	Impact on lifestyle
86	93	Aroran et al., 2014 [109]	Diabetes	Disease controls
87	93	Evans et al., 2012 [110]	Gynecology/obstetrics	Knowledge improvement
88	92	Bauer et al., 2003 [111]	Mental health disorders	Diseases control
89	92	Castano et al., 2012 [112]	Gynecology/obstetrics	Treatment adherence
90	91	Menon-Johansson et al., 2006 [113]	Gynecology/obstetrics	Disease controls
91	91	Abroms et al., 2014 [114]	Addiction	Cigarette smoking quitting
92	89	Holmen et al., 2014 [115]	Diabetes	Self-monitoring
93	89	Bereznak et al., 2012 [116]	Mental health disorders	Self-monitoring
94	88	Aguilera et al., 2011 [117]	Mental health disorders	Disease controls
95	88	Weitzel et al., 2007 [118]	Addiction	Treatment adherence
96	88	Da Costa et al., 2010 [119]	General medicine	Attendance/ appointment reminders
97	87	Naughton et al., 2012 [120]	Addiction	Cigarette smoking quitting
98	84	Haug et al., 2009 [121]	Addiction	Cigarette smoking quitting
99	84	Newton et al., 2009 [122]	Diabetes	Impact on lifestyle
100	84	Geraghty et al., 2008 [123]	ENT diseases	Attendance/ appointment reminders

Table 3: Name of journals that published 100 highly cited interventional studies on mobile health

Journal Name	Number	Impact Factor
Journal of Medical Internet Research	9	4.945
Lancet	3	59.102
Diabetes Care	3	15.27
Journal of the American Medical Association (JAMA)	3	51.273
PloS One	3	2.776
International Journal of Medical Informatics	3	2.731
Journal of Telemedicine and Telecare	3	2.229
JAMA Internal Medicine/ Archives of Internal Medicine*	3	20.768
Journal of American College Health	2	1.455
Schizophrenia Bulletin	2	7.289
BMC Psychiatry	2	2.666
Pediatrics	2	5.401
Obstetrics and Gynecology	2	4.965
Preventive Medicine	2	3.449
Nicotine & Tobacco Research	2	3.786
Telemedicine and E-Health	2	1.996
JAMA Dermatology/ Archives of Dermatology**	2	7.995
British Journal of General Practice	1	4.434
AIDS	1	4.499
British Journal of Health Psychology	1	2.472
Tobacco Control	1	6.221
Diabetic Medicine	1	3.107
JAMA Psychiatry	1	15.916
Science Translational Medicine	1	17.2
Family Practice	1	1.986
Obesity	1	3.969
Respiratory Medicine	1	3.237
Diabetes Technology & Therapeutics	1	4.488
Public Health Nutrition	1	2.526
Lab On A Chip	1	6.914
HEART	1	5.082
Medical Journal of Australia	1	5.438
Journal of Zhejiang University-Science B	1	5.438

Journal Name	Number	Impact Factor
JMIR Mhealth And Uhealth	1	4.301
Addiction	1	6.851
Heart Rhythm	1	5.225
Vaccine	1	3.269
Journal of Nutrition Education and Behavior	1	2.869
Health Informatics Journal	1	2.297
Alcoholism-Clinical and Experimental Research	1	3.235
AIDS Patient Care and STDS	1	3.742
Annals of Internal Medicine	1	19.315
Annals of Emergency Medicine	1	5.209
Circulation	1	23.054
Drug and alcohol dependence	1	3.466
BMC ophthalmology	1	1.431
Parkinsonism & related disorders	1	4.360
JAMA pediatrics	1	12.004
American journal of public health	1	3.243
Behavior therapy	1	5.381
Clinical Infectious Diseases	1	9.055
BMJ-British Medical Journal	1	27.604
Bipolar disorders	1	4.936
Journal of Epidemiology Community Health	1	3.872
European Journal of preventive cardiology	1	5.640
European Eating Disorders Review	1	3.154
Computer methods and programs in biomedicine	1	3.424
Journal of Human Nutrition and Dietetics	1	3.088
Sexually Transmitted Infections	1	3.365
Hypertension	1	7.017
Professional Psychology: Research and Practice	1	1.324
BMC pregnancy and childbirth	1	2.413
Journal of Studies on Alcohol and drugs	1	2.584
American Journal of preventive medicine	1	4.435
BMJ open	1	2.376
BMC public health	1	2.567
Journal of Developmental and Physical Disabilities	1	0.954
Journal Of Nervous and Mental Disease	1	1.859
The Journal of Laryngology & Otology	1	1.261
Total	100	

* The journal of Archives of Internal Medicine was renamed to JAMA Internal Medicine in 2012

** The Journal of Archives of Dermatology was renamed to JAMA Dermatology in 2013

Table 4: First author countries of 100 highly cited interventional studies on mobile health

Country	No. of articles
United States	45
Australia	13
United Kingdom	11
New Zealand	6
Germany	3
Spain	3
Malaysia	1
Denmark	2
Canada	2
Kenya	2
France	2
Brazil	2
Finland	1
China	1
Netherlands	1
Scotland	1
Sweden	1
Ireland	1
Norway	1
South Africa	1
Total	100

Fig 1: Distribution of 100 highly cited interventional studies on mobile health, based on publication year

DISCUSSION

This bibliometric study investigated the most cited articles on mobile health intervention. The majority of articles were published in the *Journal of Medical Internet Research*. Most articles were published in 2012. The highest impact factor among the journals under study was 59.102. The first authors of the majority of studies were from the United States.

From the 100 reviewed articles, most of the interventional studies in the field of mobile health focused on obesity (n=18), addiction (n=15), diabetes (n=13) and mental health disorders (n=12). Eighteen studies that investigated obesity used text messaging services (n=9), mobile applications (n=6), decision-support technologies, distance education and consulting, and wearable technologies (n=3). Control and experimental groups were used in all of these studies. In the majority of studies that focused on obesity (n=18), the use of mobile capabilities and other mobile technologies significantly reduced the participants' weight and corrected unhealthy lifestyle behaviours [28, 30, 38, 39, 49, 54, 60, 64, 66, 67, 75, 77, 86, 93, 101, 104, 106, 108]. Obesity has significant prevalence as a result of unhealthy lifestyles and improper eating habits. Obesity has been recognised by the World Health Organization as one of the leading causes of global mortality, as it increases the chance of developing potentially risky chronic diseases, such as diabetes, cancers, and

musculoskeletal and cardiovascular diseases [124]. ICT-based weight management interventions provide the opportunity to engage a broad audience in a more flexible and cost-effective manner. Mobile telephones may be an interesting visual intervention method because of their popularity and availability at any time and location [30, 125]. As the present study has shown, numerous studies have focused on the use of technology in losing weight.

The present study included 15 highly cited papers that discussed using mobile technology interventions for people with substance abuse issues, such as alcoholism (n=3) and chain-smoking (n=12) [26, 27, 31, 42, 53, 59, 71, 87, 90, 105, 107, 114, 118, 120, 121]. Nine text messages and six mobile telephone-based applications were used in these studies. In most studies, the use of text messaging services led to a decrease in drug use for either smoking or alcohol consumption [26, 42, 53, 71, 87, 105, 114, 118, 120, 121]. Overall, in these studies, according to Statista's report [126], informing individuals about the risks of tobacco use, increasing prices, applying certain policies, and implementing purposeful activities can all significantly minimise substance abuse. The text messaging feature of smart telephones can be easily used at any time and place, is cost-effective and is scalable to large crowds, regardless of the individual's location. Moreover, the ability to personalise messages with key user features (such as age, gender and ethnicity) can help control or stop smoking [127]. Studies have shown that sending

time-sensitive messages with content that may prevent the user from reusing tobacco is another mobile telephone solution for smokers [26, 42, 53, 71, 87, 105, 114, 118, 120, 121].

It should be noted that, while a limited number of studies have focused on the role of text messages in helping individuals quit smoking, the use of mobile applications and multimedia messages has not effectively ceased this type of substance abuse [53, 107, 114]. This may be due to the unwillingness of users to install and employ mobile-based applications. Moreover, in one study, Whittaker et al. [107] found that they could not assess the effect of this technology through a limited random selection of smokers aged 16 and 24 years because, despite the participants' interest in quitting smoking, younger people do not accept interventions for quitting. However, their study was published in 2011, so it is possible that society's perspective has changed over time regarding the risks of drugs, and future studies could examine the effect of mobile application interventions on reducing and ceasing the use of tobacco or other addictive substances. As reported by Statista, the prevalence of smoking among individuals aged 15 to 24 had decreased to 19.1% in 2000 and will decrease to 12.3% by 2025 [128].

Based on the results of the present study, the third category of highly cited interventional studies was undertaken in the field of diabetes (n=13). These studies applied text messaging services (n=6), mobile applications (n=4), distance education and remote monitoring systems (n=3) for disease control, self-monitoring, adherence to treatment and increasing physical activity [29, 32, 45, 58, 65, 68, 85, 89, 91, 94, 109, 115, 122]. In most studies, the use of the potential of mobile telephones and their technologies reduced blood glucose levels, metabolic control, drug administration and adherence to recommended treatments among diabetic patients [29, 32, 45, 58, 65, 68, 85, 89, 91, 115, 122]. In recent years, diabetes has become one of the leading causes of mortality worldwide. According to the World Health Organization, approximately 1.6 million people died of diabetes in 2016, and it is estimated that 425 million people live with diabetes across the world [129]. Moreover, this number is predicted to increase to about 629 million worldwide by 2045 [129]. Modifying lifestyle, increasing physical activity, following a healthy diet and avoiding drug abuse can reduce the risk of diabetes. In addition, early diagnosis of the disease can prevent its later consequences [130, 131]. The prevalence of smartphones and mobile technologies around the world may be an effective means for preventing and controlling diabetes, as the studies reviewed in this article indicated this approach to be effective.

Among the 100 highly cited studies examining the effect of mobile technology and its capabilities for

mental illnesses, 12 studies were investigated [33, 40, 47, 48, 53, 76, 79, 82, 97, 111, 116, 117]. The majority of the studies used mobile apps (n=8), while the remainder used text messaging systems (n=4). In these studies, the use of mobile telephone capabilities improved disease control, health-related symptoms and self-monitoring among patients [33, 40, 47, 48, 53, 76, 79, 82, 97, 111, 116, 117]. At present, mental health disorders are increasing worldwide, with 284 million people suffering from anxiety [132]. The psychological disorders studied in the highly cited studies included depression, anxiety, bipolar and borderline disorders, schizophrenia, binge eating disorder and autism. However, despite the significance of mental health disorders and their wide range, limited studies have been conducted in this area. Thus, future studies could investigate the potential of mobile telephones and their technologies for controlling and treating all mental health disorders.

Eight of these studies investigated the potential of mobile telephones for addressing viral diseases, especially human immunodeficiency virus (HIV). In most related studies, text messaging services (n=6) were used to encourage adherence to antiviral treatment among HIV patients [24, 25, 69, 70, 74, 80]. In addition to the effect of text messaging, the use of mobile apps in one study also improved adherence to treatment among these patients [83]. Only one of the studies examined the effect of contextual reminders for vaccination for human papillomavirus [63]. In 2018, almost 37.9 million people were living with HIV in Iran. Among these people, 36.2 million were adults and 1.7 million were children (younger than 15 years) [133]. Meanwhile, human papillomavirus is the leading cause of cervical cancer—the fourth most common cancer among women. According to the World Health Organization, in 2012, this virus had killed 226,000 people around the world [134]. In addition, according to the statistics published by the World Health Organization, 85% of the global cases of the virus have occurred in less developed countries [134]. Therefore, considering the importance of these viruses in risking the health of people, as well as their potential for transmission, it is important to use all available interventions for the follow-up and control of these diseases. Future studies could investigate the effect of mobile interventions on the follow-up, control and treatment of these diseases and other risky viral diseases.

The other highly cited papers respectively investigated the effect of the potentials of mobile telephones and other mobile technology interventions on cardiovascular disease, pregnancy and postpartum care, sexual health knowledge promotion, melanoma and ovarian cancer diagnosis, malaria control, Parkinson's disease control, hepatitis control, postoperative care of liver transplantation, eye and ear diseases, pharynx and

nose diseases, and sun care [34-37, 41, 43, 44, 46, 50-52, 56, 57, 61, 62, 72, 73, 78, 81, 84, 88, 92, 95, 96, 98-100, 102, 103, 110, 112, 113, 119, 123]. The variety of health care domains investigated in these studies reflects the changes in mobile health care research trajectories over the past 20 years. The majority of studies employed the most affordable and accessible mobile text messaging services to control diseases and encourage adherence to disease treatments.

This study had four limitations. The first limitation was that the self-citations and citations given in books and other texts were not investigated. This is based on the policies of calculating the number of citations in the WOS database [7]. The second limitation was that the list of highly cited papers is not fixed and changes over time. Our search strategy was run in August 2020, and the number of citations and article order may change after a period of time. Third, our literature search was restricted to the English language. Articles published in languages other than English may have received unfair citation counts because of bias and poor recognition in the field. Fourth, this study only examined the mobile technology interventions that published in WOS. Maybe most of widely used mobile technologies are not necessarily mentioned in scientific papers in WOS, but are using in public and maybe some of them are just designed as a marketing project. Therefore, future studies can pay attention to this issue.

Numerous studies have investigated highly cited studies in the fields of medical informatics [11], telemedicine [12] and mobile health [19]. In this study, highly cited articles were selected, and the number of citations, number of authors, impact factor of journals, organisational affiliation and country of each article were reviewed. Moreover, this study focused on mobile health and only examined the bibliometric features of all highly cited papers published in this field over a 10-year period (2006 to 2016) [19]. However, the present study was able to classify highly cited interventional mobile health studies. In our study, the most cited article focused on treatment adherence among HIV patients.

CONCLUSION

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Among the 100 reviewed articles, the majority of the interventional mobile health studies focused on obesity, addiction and diabetes. The increased number of citations for articles investigating obesity, addiction and diabetes shows the rising prevalence of these problems in contemporary societies. This also indicates the importance of these diseases and their aftermath. As a result, several studies have examined the effect of mobile technologies on weight loss, physical activity, drug use control and blood glucose control. Based on the results of the present study, there was only one highly cited article about each of the following areas: cancer; neurological diseases; and eye, ear, throat and nose problems. The interventions used in most of the studies were text messages through text messaging services. Few studies have examined the effects of mobile applications and other mobile technologies. Future studies can examine the effects of different mobile applications on various diseases' prevention, control and treatment.

ACKNOWLEDGEMENT

The authors are grateful to the Medical Informatics Research Center of Kerman University of Medical Sciences.

AUTHOR'S CONTRIBUTION

A. Ameri, F. Salmanizadeh, and K. Bahaadinbeigy were the responsible for the study design, data analysis, interpretation of results, and writing the manuscript.

The authors agree on this final form of the manuscript, and attested that all authors contributed in the final draft of the manuscript.

CONFLICTS OF INTEREST

The authors declare no conflicts of interest regarding the publication of this study.

FINANCIAL DISCLOSURE

No financial interests related to the material of this manuscript have been declared.

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