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Technology in psychology: a bibliometric analysis of technology-based interventions in clinical and health psychology

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ABSTRACT

This study aimed to identify, synthesize, and evaluate the current state of research on the use of technology-based interventions in clinical psychology through 2017 as a recent innovative area of study. It was intended to provide a critical overview of trends in different tools and populations and identify future areas of interest. This paper focuses on studies published in psychological interventions in childhood, adolescents, adults, and geriatric populations using new technologies, including web-based intervention, virtual reality, augmented reality, mobile applications, and robotics, with particular attention to methodology. To achieve this aim, a systematic search was made in the ISI Web of Science for intervention, psychology, and the technological tools previously mentioned. The results of the study show that the use of information and communication technologies in psychology has been an innovative and growing field of study for the last 10 years. In total, 743 were included in this study. A growing trend has been observed in publications related to psychology and the use of technologies since 2007. Resea0rch topics were focused mainly on interventions on specific problems or disorders such as depression. The largest number of publications were found for the web-based intervention, in randomized clinical trials and applied to adults

KEYWORDS

Bibliometric; clinical psychology; health psychology; information and communication technologies; scientometric

Introduction

The use of technology has caused a change in perspective in many scientific disciplines, among them clinical and health psychology. Indeed, this was suggested by Holmes et al.[1] in *The Lancet Psychiatry Commission*, in which the use of Information and Communications Technologies (ICT) was presented as an opportunity for progress in psychology. Specifically, in clinical and health psychology, ICT can provide innovations to strengthen treatments, allowing the adaptation of psychological therapies in brief, flexible, and worldwide accessible formats.[1]

The use of ICT offers psychological interventions some advantages. For example, the use of Virtual Reality (VR) or Augmented Reality (AR) adds value to exposure therapy,[2] providing the development of virtual scenarios that safely produce emotional reactions similar to real contexts.[3] The use of web-based interventions allows access to treatment for a larger number of patients without having to be in the same place and at any time of the day.[4–6] The low accessibility to evidence-based treatments is an important limitation in the field of clinical psychology.[7] ICT can also provide new resources or tools to improve assessment and treatment procedures, for example, it can provide information and assessment at the moment and in the real context, that is *Ecological Momentary Assessment* (EMA),[8] which is an opportunity to improve the

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psychometric and ecological validity of psychological instruments of assessment. Besides, because of the new mobile devices, ICT makes it possible to conduct the intervention in natural contexts, which is *Ecological Momentary Interventions* (EMI),[9] which can facilitate the generalization of the learned skills. However, several disadvantages are found in applying ICT to clinical psychology, for example, it is difficult to certify that the patient is carrying out the intervention, while it is necessary to improve the confidentiality of the data. Likewise, the initial costs for the development of the technology are high, requiring technical skills and specific devices. It can have different types of dependencies on the patient, and it is easy to find prejudices and rejections by the therapists.[10]

The objective of this study is to review and make a bibliometric analysis of the use of ICT in clinical and health psychology, that is, to perform a quantitative analysis of scientific production in this field. To this end, a systematic search of the literature of the main ICT used in psychology was carried out, following the classification of behavioral intervention technologies in a review by Mohr et al.[4]: including VR, web-based, serious games, mobile devices, and also robotics.[11]

Review of technologies applied to clinical and health psychology

Virtual reality and augmented reality

Virtual Reality (VR) is defined as the use of virtual scenarios in which the participant has the feeling of being immersed in it and interacting with stimuli from the scenario to implement the intervention.[5] Regarding psychological interventions, VR in combination with the traditional evidence-based intervention was found to be an effective tool for treating phobias,[12] anxiety, and depression symptoms,[2,13] in patients with schizophrenia,[13,14] eating disorders,[13,15] among others. Despite this promising data, it is important to highlight the importance of the therapeutic content and the technology backing up its efficacy, more than the technology *per se*, that is, the use of ICT for clinical intervention is not the answer to the psychological problem or diagnosis, but it is important to validate the therapeutic content. Augmented Reality (AR), one of the ICTs on the Milgram and Kishino[16] reality-virtual continuum, consists of including virtual elements in a "real world" which can be viewed through a device. Similar to VR, RA has shown positive effects in reducing phobias in a similar way to exposure in vivo[17,18] and with similar effects than VR with anxiety.[19] Also, augmented reality can increase the level of motivation and attention in children with autism, improving the perception of emotions.[20]

Web-based interventions

Telepsychology or web-based interventions are defined as the administration of health from a distance, whether over the Internet, through a self-applied web page, videoconferencing, etc.[21,22] Online treatments or those applied over the internet for prevention may be effective in reducing risk[23] as well as the prevention and treatment of mental health.[24] Specifically, web-based interventions have shown positive effects in the reduction of affective symptoms of anxiety and depression disorders,[25] stress symptoms,[26] chronic pain,[27] or eating disorders.[24] As in anxiety, a reduction in symptoms is observed, but they are not maintained in the long term.[23,24]

Serious games

An ICT employed in clinical psychology which is especially attractive for children and youth is serious games, educational, preventive, or intervention software, but with specific objectives for psychological treatment or health.[28,29] The use of serious games has been related to an improvement in cognitive skills such as memory, problem-solving, and attention tasks. Besides, motivational level encourages learning and understanding of content.[30,31] For example, the use of serious games has

shown benefits in children with Attention Deficit Hyperactivity Disorder (ADHD),[32,33] in anxiety symptoms,[34] and symptoms derived from post-traumatic stress disorder.[33] Besides, there is a reduction in depressive symptoms in adolescents and promotes social skills in children diagnosed with autism.[33]

Mobile's devices

Additionally, the software for psychology has also been developed as cell phone applications (Apps) for implementing psychological interventions, or mHealth. The use of cell phones for health and psychology provides important benefits as mentioned above, such as EMA and EMI.[8,9] Mobile devices have some features that can be very useful for clinical practices such as gyroscope, Global Positioning System (GPS), camera, etc. Also, it is easy to connect the smartphone with other devices and senses of biofeedback that allow the monitoring of psychophysiological aspects such as heart rate.[35] A review by Menon, Rajan, and Sarkar[36] found positive effects using Apps to reduce depressive symptoms, improve monitoring in bipolar disorder, reduce anxiety symptomatology, stress, and improve coping strategies in anxiety disorders, reduce psychotic symptoms, and reduce substance use. Although these positive effects on mental health are found, the support of the mental health professional is a moderator of the effects of the intervention.[37]

Robotics

The use of social robots is another of the ICT employed in clinical and health psychology. A social robot is an automated system provided with artificial intelligence with the ability to interact in a social setting[38] which has as its purpose an affective relationship for rehabilitation, learning[39] through these interactions to create a supportive context for general positive skills for a living.[40] The intervention supported by a robot can be useful, for example, for children with autism spectrum disorder.[41] However, human involvement is necessary. Similarly, social robots show improvements in well-being in older adults. This technology can improve the levels of stress, anxiety, quality of life, and loneliness in people with dementia or cognitive impairment.[42]

Purpose of the study and research questions

Bibliometrics is commonly used to measure scientific output to understand the development of an area of knowledge and the evolution of publications.[43] To our knowledge, no publications are covering this objective and the benefits and advantages of the use of ICT in clinical and health psychology have been pointed out.[1] This paper aims to study the body of ITC and interventions in clinical and health psychology literature employing bibliometric procedures, following a similar methodology as previous studies.[44,45] For this purpose, the studies found are analyzed based on different research questions. To analyze the evolution of publications from the beginning to the present (RQ1: *How many articles on psychological intervention through ICT have been published in JCR (Journal Citation Reports) journals?*), to check what type of technology is used according to the age and diagnosis of the participants (RQ2: *Which technologies are employed the most for psychological intervention? Are technologies different depending on the type of population?*), the research methods used (RQ3: *Which journals publish studies about psychological intervention through ICT most frequently?*), and the areas of knowledge that make use of this tool and which countries publish on this topic (RQ4: *What research methods are used in studies of psychological intervention through ICT? What journals publish these studies by research method?* and RQ5: *What are the main countries that publish studies of psychological intervention through ICT? What other areas of knowledge publish studies using ICT for treatments or interventions?*). Given these objectives, the present study can be useful to update knowledge and observe the progress of the use of technology in psychology. It can also be a tool for decision-making in the design of research and publication strategies.

This paper includes journals indexed in the Journal Citation Reports (JCR) as a widely used indicator of quality. It can be assumed that journals with higher impact factors are the most prestigious. The quality of papers published has been considered as having high-quality peer-reviewed publications.[46]

Method

Data sources and search strategy

ISI Web of Science electronic database was searched systematically. There was no time limit (up to December 2017) in the search strategy, that is, there was no specified start date for the search. The following search terms were used: "psychol*" AND "intervention" in combination with "web," "robot," "virtual reality," "app" y "augmented reality," the searching terms were selected following the classification of Mohr et al.[4] See Appendix A for the search strategy.

Sample selection

Once obtained the results of the systematic search articles, the PICOS strategy (Participants, Intervention, Comparison, Outcome, Study design) was used to define the research question with clear inclusion criteria. This bibliometric paper included studies applied (P) to all types of population (children, adolescents, adults, geriatric population) in the field of clinical and health psychology, including studies for a nonspecific population (that is, systematic reviews); (I) who receive an intervention that used technology in at least one of the components, among which is included in the classification of Mohr et al.[4]: mobile devices, web-based intervention, virtual reality (including augmented reality), serious games, and also robotics, (C) in all comparison conditions (including no comparison), (O) to promote psychological problems, Physical or specific concerns psychological disorder in (S) all design studies. Articles were excluded if the studies are letters to the editor, abstracts of communications, symposia, and book reviews.

The initial search was done by the first author, who identified the studies that met the inclusion criteria of titles and abstracts. Duplicated were eliminated. The studies were analyzed by reviewing the full text, and decisions on the inclusion of the article were made through a discussion.

Data extraction and analysis

The following variables were extracted from the articles including (see Appendix B for more details):

(a) Kind of technology used; based on the procedure section of articles we classified in mobile devices (including cell phones, tablets, etc.), robots, serious games, virtual reality, and web-based interventions. We also included general technologies for studies that are not technology-specific or combine ICT solutions.
(b) Topic or diagnosis to which the publication is directed.
(c) Kind of population: children, youth, young adults (for university students), adults, geriatric, and non-specified.
(d) Research method: studies of validation or development of assessment instruments (assessment); correlational studies, case studies (including case series studies), studies of software design or development, protocol studies, pilot studies, theory studies, quasi-experimental design, qualitative design, systematic review, meta-analysis, randomized controlled trials (RCT), and studies of usability or ergonomics.
(e) Year of publication.
(f) Journal of publication.
(g) Country of study, for this, the country of the first author was taken as reference.

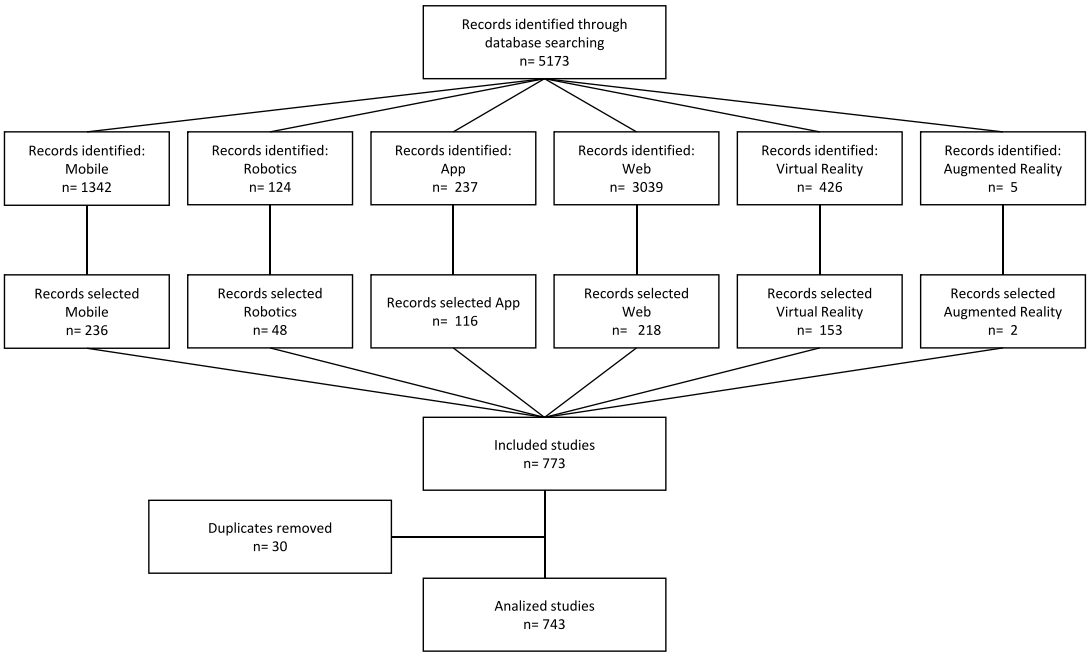

Figure 1. PRISMA Flow Diagram of identified and included studies.

(h) Knowledge area in which the study is framed. For this, the department or place of work of the first author was taken as a reference.

As to data analysis, firstly, a descriptive analysis of the frequency and percentage of each variable was done. To analyze the statistical differences to the expected frequencies, the Chi-square nonparametric test (x^2) was done and adjusted standardized residuals were used for highlighting contribution to chi-square. To explore the power effect of association the Cramer's V was used. A Cramer's V of .1 is considered to be a small effect, .3 a medium effect, and .5 or larger a large effect.[47]SPSS Statistics 21 statistical software was employed.

Results

The first search identified a total of 5173 studies from all the search topics. Specifically, 1342 studies were identified in the search on cell phones, 124 studies on robotics, 237 studies on applications (Apps), 3039 Web studies, 426 studies on virtual reality, and 5 on augmented reality. Of these studies, 773 which met the criteria for inclusion for analysis were finally selected for the study. Two hundred and thirty-six were on mobile devices, 48 on robotics, 116 on Apps, 218 related to the internet (or Web), 153 on virtual reality, and two on augmented reality. After eliminating duplicates, the 743 studies remaining were finally analyzed (Figure 1).

RQ1: How many articles on psychological intervention through ITCs have been published in JCR journals?

The increase in publications on the use of ICT in psychology may be observed in Figure 2. The first study was published in 1988[48] in a theoretical review of the implications of robotics in occupational psychology. From 2007 on, an upward trend in publications (n = 11) is observed. In 2013 (n = 91) the greatest increase in publications on this subject matter from previous years is observed. The year with the most publications was 2017 (n = 120).

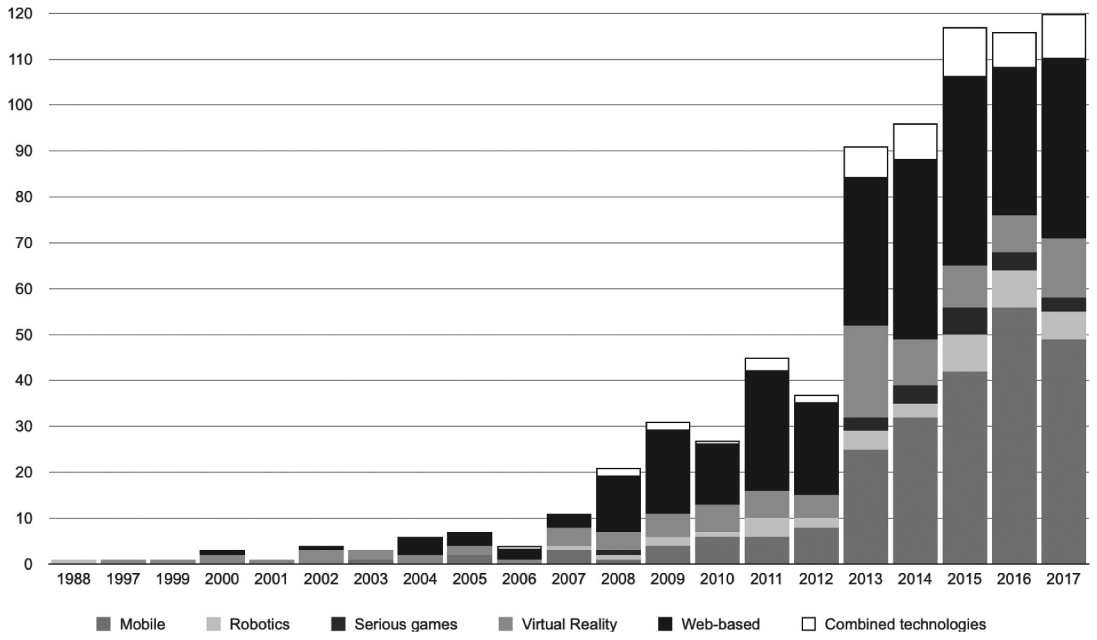

Figure 2. Trend of publications on technology-based treatments and psychology.

The first publications on cell phones (n = 2) appeared in 2005. One of them was a theoretical review of interventions for obesity using cell phones.[49] The other publication, the same year, was a quasi-experimental study in the field of health on parent–child interaction for monitoring glucose in Type 1 Diabetes.[50] In 2008, the first article on serious games was published, it was a review of strategies for children and adolescents.[51] In 1997, the first study on VR, a review of opportunities for using VR in psychology, was published.[52] Finally, at the end of 2000, an evaluation for professionals on the use of the internet for psychological consultation was published.[53]

Table 1 shows the relative frequencies of publications in the last 5 years. Publications on the use of cell phones have increased in recent years and have been more frequent since 2015. In 2017, it was the area with the most scientific production (40.83%). Publications on the use of web-based or interventions administered over the internet made up another 32.5% in 2017. The ICT with the fewest publications is serious games with only 2.5%.

The topics of research have also changed over the years. In the beginning, the research was focused mainly on interventions in phobias or non-clinical samples, while currently, it focuses on specific problems or disorders such as depression, mental health, or substance abuse. Similarly, research methods have varied, initially consisting of theoretical articles or case studies while currently being systematic reviews, meta-analyses, or RCT.

RQ2. Which technologies are most used for psychological intervention? Are technologies different depending on the type of population?

The ICT employed the most in studies, and therefore, with the largest number of publications, was found to be the use of the internet and websites (n = 286; 38.5%), followed by the use of cell phones (n = 235; 31.6%), virtual reality (n = 105; 14.1%), robotics (n = 41, 5.5%), and lastly, serious games (n = 21; 2.8%). Also, 7.4% of the studies were not aimed at a specific technology or were combined with ITC (n = 55), that is, these were theoretical studies, reviews, or with more than one type of ICT (Figure 3).

Table 1. Overview of the included studies (N = 743).

	MOBILE (n = 235)	ROBOT (n = 41)	SG (n = 21)	TECH (n = 55)	VR (n = 105)	WEB (n = 286)	N (N = 743)	%
YEAR (LAST 5 YEARS, n = 540) – n (%)								
2013	25 (27.4)	4 (4.4)	3 (3.3)	7 (7.6)	20 (21.9)	32 (35.1)	91	12.2
2014	32 (33.3)	3 (3.1)	4 (4.1)	8 (8.3)	10 (10.4)	39 (40.6)	96	12.9
2015	42 (35.9)	8 (6.8)	6 (5.1)	11 (9.4)	9 (7.6)	41[35]	117	15.7
2016	56 (48.28)	8 (6.9)	4 (3.4)	8 (6.9)	8 (6.9)	32 (27.5)	116	15.6
2017	49 (40.83)	6[5]	3 (2.5)	10 (8.3)	13 (10.8)	39 (32.5)	120	16.2
POPULATION								
Children	14	19	6	4	21	12	76	10.22
Young	19	2	0	5	9	32	67	9.01
Young adults	5	0	0	1	1	1	8	1.07
Adult	145	7	8	18	55	187	420	56.5
Geriatric	3	10	3	2	6	10	34	4.6
Non-specified	49	3	4	25	13	44	138	18.57
DISORDER[a]								
Depression	38	5	5	5	3	72	128	17.2
Substance abuse	39	0	2	3	3	23	70	9.4
Mental health	26	1	0	8	2	21	58	7.8
Eating disorders	25	0	1	4	7	14	51	6.9
TEA	5	16	3	5	10	1	40	5.4
Non-clinical	11	2	3	6	3	14	39	5.2
Pain	5	0	1	2	16	10	34	4.6
PTSD	7	0	0	1	9	17	34	4.6
Cancer	6	1	0	0	6	14	27	3.6
Affective disorders	11	0	0	6	2	6	25	3.4
STUDY DESIGN								
Assessment	15	0	0	2	3	5	25	3.4
Correlational	7	0	0	2	4	5	18	2.4
Case study	7	6	2	2	9	3	29	3.9
Design	18	5	3	2	7	18	53	7.1
Protocol	21	0	0	2	2	30	55	7.4
Pilot study	26	7	1	3	10	23	70	9.4
Theory	15	2	1	4	2	11	35	4.7
Quasi-experimental	29	9	3	1	21	22	85	11.4
Qualitative	7	0	0	1	2	9	19	2.6
Systematic Review /Meta-analysis	35	5	7	32	18	44	141	19
RCT	34	6	2	3	18	99	162	21.8
Usability	21	1	2	1	9	17	51	6.9
COUNTRY[a]								
USA	64	9	6	15	33	121	248	33.4
UK	26	3	4	15	9	22	79	10.6
Australia	24	6	0	3	13	21	67	9
The Netherlands	23	3	3	2	12	19	62	8.3
Spain	13	1	1	4	6	17	42	5.7
Germany	13	0	0	2	3	19	37	5
Canada	7	4	3	4	5	6	29	3.9
Italy	7	3	0	1	1	8	20	2.7
Sweden	2	1	2	1	4	8	18	2.4
Switzerland	4	0	0	3	0	7	14	1.9
AREA OF KNOWLEDGE								
Psychology	86	11	10	15	35	94	251	33.8
Others	35	9	4	11	17	39	115	15.5
Medicine	31	1	2	9	15	52	110	14.8
Non-specified	29	6	0	3	3	23	64	8.6
Engineering	12	8	0	5	12	21	58	7.8
Psychiatry	11	1	1	8	7	26	54	7.3
Nursing	10	2	3	1	7	11	34	4.6
Rehab/Physiotherapy	16	1	0	1	8	6	32	4.3
Neuroscience	4	1	1	0	1	7	14	1.9
Pediatrics	1	1	0	2	0	7	11	1.5

[a]The 10 most frequent are presented

Concerning the type of population, it was found that the publications have been mainly on adults (n = 420; 56.6%), followed by children (n = 76; 10.22%), youth (n = 67; 9.01%), geriatric (n = 34; 4.6%), and youth adults (n = 8; 1.07%). There are also many publications that are not directed at any specific type of population (n = 138; 18.57%).

Furthermore, most of the publications devoted to the adult population employed web-based strategies to carry out interventions (n = 197) followed by using cell phones (n = 148). For children, most of the publications reported on the use of virtual reality (n = 21). For adolescents, web-based interventions (n = 32) and mobile devices (n = 19) are used the most. For geriatric population, robotics (n = 10) and web-based (n = 10) intervention are more frequent (see Table 1)

Pearson's x^2 analyses indicated that there was a significant interaction between type of technology and population ($x^{2(45)}$ = 75.749, p <.005), in which the power of association was small (V =.23). Specifically, studies on mobile devices were more likely for youth adults; studies on robots were more likely for children; studies on serious games were more likely for children; studies on virtual reality were more likely for children; and studies on web-based intervention were more likely for adults.

Concerning the topic of studies, we found 42 topics among the studies, in most of the studies, the objective was intervention in depression (n = 128; 17.2%), performed to a greater extent employing the internet (n = 72). Substance use (n = 70; 9.4%) in which the cell phone was employed most often.[39] Finally, for mental health (n = 58; 7.8%), the cell phone was used the most (n = 26) (see Table 1 the most frequent topics and Figure 4)

Dividing the sample by population type, adults with depression (n = 97; 21.4%), substance use (n =48; 10.6%), and posttraumatic stress disorder (PTSD) (n = 29; 6.4%) were more frequents. In childhood, ICTs are used more often in Specific Learning Disorder (SLD) (n = 28; 38.4%), depression (n = 8; 11%) and Acquired Brain Damage (ABD) (n = 6; 8.2%). In adolescents, technologies are more frequent used for promoting mental health (n = 12; 17.9%), Substance Abuse (n = 12; 17.9%), eating disorders (n = 8; 11.9%) and Autism Spectrum Disorder (ASD) (n = 8; 11.9%). In geriatric population it is used more frequently for dementia (n = 15; 44.1%).

Pearson's x^2 analyses indicated that there was a significant interaction between type of technology and topic of study (x^2 (205) = 551.91, p <.001), in which the power of association was moderate (V =.34). Specifically, studies on mobile devices were more likely for substance abuse, studies on robots

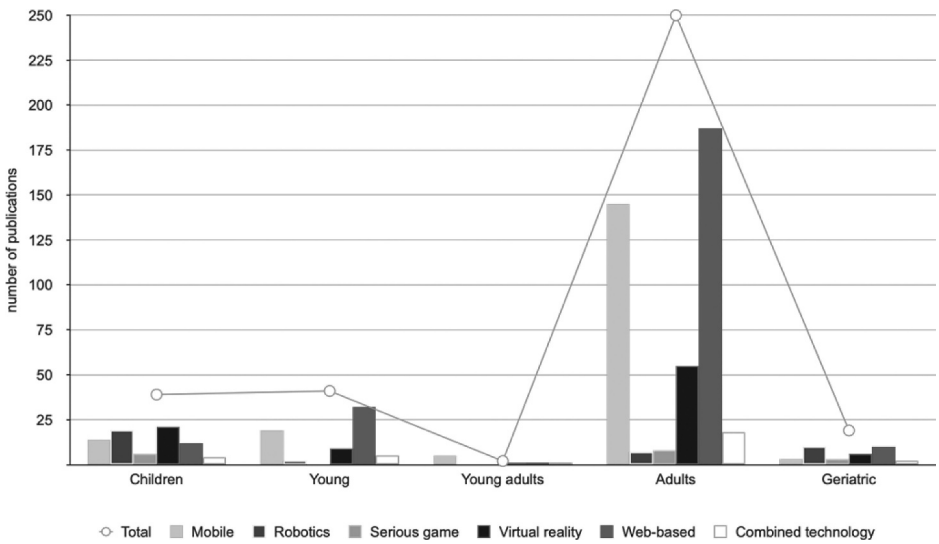

Figure 3. Number of publications by kind of technology.

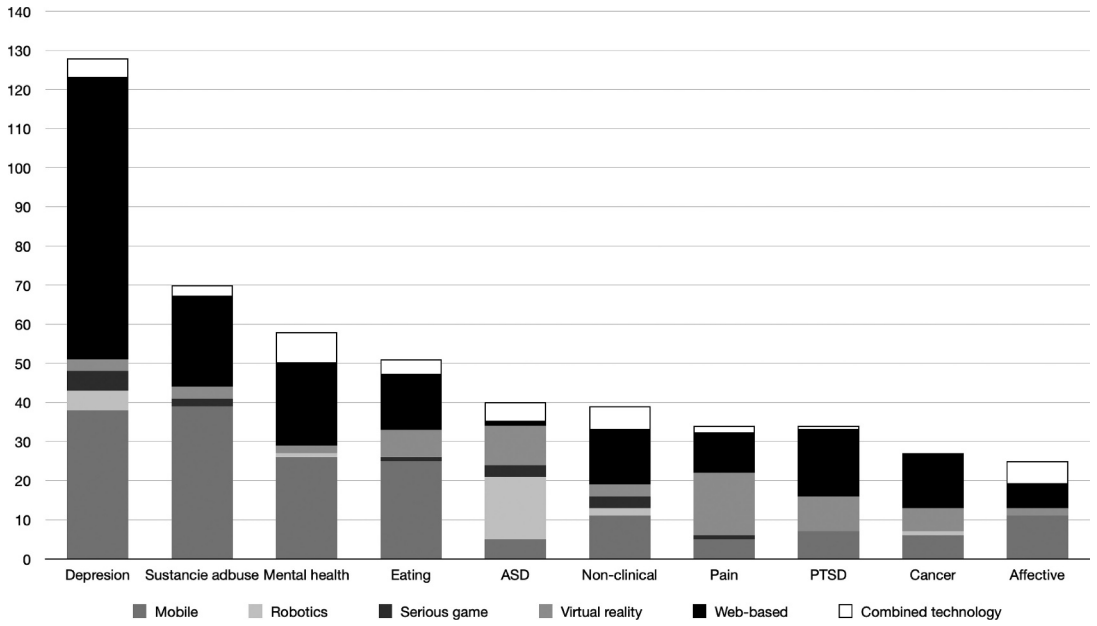

Figure 4. Number of publications by psychological disorder and kind of technology.

were more likely for ASD, studies on serious games were more likely for non-clinical studies; studies on virtual reality were more likely for fear, and studies on web-based interventions were more likely for depression.

RQ3: Which journals publish studies about psychological intervention through ICT most frequently?

There was also variability in the journals that publish studies related to the application of the ICT in psychology. We found 325 different journals that show a certain acceptance in their editorial lines of general journals, that is, most of the publications were not concentrated in only a few specialized journals. It should be emphasized that the *Journal of Medical Internet Research* published 11% (n = 82) of the articles in this field, followed by the *BMC Psychiatry* (3.6%; n = 27) and *Trials* (2.7%; n = 20). Most of the publications in these three journals dealt with web-based treatments (*Journal of Medical Internet Research* (n = 54), *BMC Psychiatry* (n = 18), and *Trials* (n = 9)) (Table 2). These journals are within two first quartiles in JCR.

According to the type of ICT employed in the studies (see in Table 3 the most frequent journals), we found that the *Journal of Medical Internet Research* had the most publications on cell phone technology with 9.4% (n = 22), use of technology in general (9.1%; n = 5) and use of websites or internet for psychological intervention (18.9%; n = 54). Studies using robots were published mostly in the *Journal of Autism and Developmental Disorders* (12.2%; n = 5). Publications on serious games (9.5%; n = 2) and virtual reality (5.7%; n = 6) were published most often in *Cyberpsychology, Behavior, and Social Networking*. Similarly, these journals are also located within the first quartile in JCR.

RQ4: What research methods are used in studies of psychological interventions through ICT? What journals publish these studies by research method?

The type of experimental design employed most frequently in the studies was RCT (n = 162, 21.8%), systematic reviews and meta-analysis (n = 141; 19%), and quasi-experimental studies (n = 85; 11.4%).

Table 2. Number of publications by journal.

	Impact factor 2016	5 year impact factor	MOB	ROB	SG	TEC	VR	WEB	N	%
J Med Internet Res	5.175	5.835	22	0	0	5	1	54	82	11
BMC Psychiatry	2.613	3.119	7	0	0	2	0	18	27	3.6
Trials	1.969	2.203	8	0	0	2	0	9	20	2.7
JMIR Research Protocols	5.175	5.835	4	0	1	1	1	6	13	1.7
J Autism Dev Disord	3.321	4.099	1	5	1	3	2	0	12	1.6
PLOS One	2.806	3.394	3	1	0	1	3	4	12	1.6
BMC Public health	2.265	2.814	4	0	0	0	0	5	9	1.2
Cyberpsychol Behav Soc Netw	2.571	3.866	1	0	2	0	6	0	9	1.2
JMIR Mhealth and Uhealth	4.636	4.463	9	0	0	0	0	0	9	1.2
JMIR Mental Health	5.175	5.835	3	0	0	1	0	4	8	1.1

Table 3. Journals and number of publications by kind of technology.

	Impact factor 2016	5 year impact factor	n	%
MOBILE (N = 235)				
J Med Internet Res	5.175	5.835	22	9.4
JMIR Mhealth And Uhealth	4.636	4.463	9	3.8
Trials	1.969	2.203	9	3.8
Bmc Psychiatry	2.613	3.119	7	3
ROBOT (N = 41)				
J Autism Dev Disord	3.321	4.099	5	12.2
Journal of The American Medical Informatics Association	3.698	3.971	4	9.8
International Journal of Social Robotics	2.559	2.507	3	7.3
IEEE Transactions on Neural Systems and Rehabilitation Engineering	3.410	3.749	2	4.9
SERIOUS GAME (N = 21)				
Cyberpsychol Behav Soc Netw	2.571	3.866	2	9.5
Games for Health Journal	2.019	2.242	2	9.5
JMIR Serious Games	5.175	5.835	2	9.5
GENERAL TECHNOLOGIES (N = 55)				
J Med Internet Res	5.175	5.835	5	9.1
Behavior Research and Therapy	4.064	4.750	4	7.3
J Autism Dev Disord	3.321	4.099	3	5.5
Bmc Psychiatry	2.613	3.119	2	3.6
VIRTUAL REALITY (N = 105)				
Cyberpsychol Behav Soc Netw	2.571	3.866	6	5.7
Cyberpsychology & Behavior	2.71	2,732	5	4.8
IEEE Transactions on Neural Systems and Rehabilitation Engineering	3.410	3.749	5	4.8
WEB (N = 286)				
J Med Internet Res	5.175	5.835	54	18.9
BMC Psychiatry	2.613	3.119	18	6.3
Trials	1.969	2.203	9	3.1
JMIR Research Protocols	5.175	5.835	6	2.1

[a]4 more frequent journals are presented.

The type of ICT most employed in the studies was the cell phone in systematic reviews or meta-analysis (n = 35; 14.9%) and RCT (n = 34; 14.5%). The studies employing robots employed quasi-experimental designs (n = 9; 22%), pilot tests (n = 7; 17.1,%), and case studies (n = 6; 14.6%) most often. In the use of serious games, systematic reviews and meta-analyses were the most frequent (n = 7; 33.3%), followed by design studies (n = 3; 14.3%), and quasi-experimental studies (n = 3; 14.3%). In virtual reality-based studies, the most frequently used were the quasi-experimental design (n = 21; 20%), systematic reviews, and meta-analysis (n = 18; 17.1%), and RCT (n = 18; 17.1%). Finally, RCT (n = 99; 34.5%), systematic reviews and meta-analysis (n = 44; 15.4%), and protocol studies (n = 30,10.5%) were used most frequently for study designs that employed the internet and web intervention.

Pearson's x^2 analyses indicated that there was a significant interaction between type of technology and research method (x^{254} = 185.325, p <.001), in which the power of association was small (V =.22). Specifically, studies on mobile devices were significantly more likely for assessment studies. Studies on robots were significantly more likely for case studies. Studies on serious games were significantly more likely for systematic reviews and meta-analyses. Studies on virtual reality were significantly more likely for quasi-experimental design. Studies on web-based intervention were significantly more likely for RCT.

Figure 5 shows the chronological progress of experimental design, finding that qualitative and quasi-experimental designs have been used since 2007 onward more than experimental studies (RCT). In any case, the trend of experimental tests was upward until 2016 when they started to fall off and experimental and quasi-experimental studies and qualitative studies rose.

The experimental designs published most frequently were, by journal, experimental protocol studies in *Trials* (n = 15; 27.3%), ICT design in *IEEE Transactions in Neural Systems and Rehabilitation Engineering* (n = 6; 11.3%), descriptive or correlational designs in *Studies in Health Technology and Informatics* (n = 4; 22.2%), case studies in *Journal of Autism and Developmental Disorders* (n = 3; 10.3%), and theoretical studies in *Annals of Behavioral Medicine* (n = 2; 5.7%). The *Journal of Medical Internet Research* published RCT the most frequently (n = 31; 19.1%), systematic reviews and meta-analyses (n = 20; 14.2%), quasi-experimental studies (n = 6; 7.1%), evaluation-related studies (n = 5; 20%), qualitative studies (n = 5; 26,3%), usability or accessibility studies (n = 5; 9.8%), and pilot tests (n = 3; 4.3%).

RQ5: What are the main countries that publish studies of psychological intervention through ICTs? What other areas of knowledge publish studies using ICT for treatments or interventions?

The countries with the most scientific production in the field of clinical psychology and the ICTs were the USA (n = 284; 33.4%), the UK (n = 79; 10.6%), Australia (n = 67; 9%), the Netherlands (n = 62; 8.3%), and Spain (n = 42; 5.7%). The USA was the country with the most scientific production in all the ICT. We found production in 36 different countries.

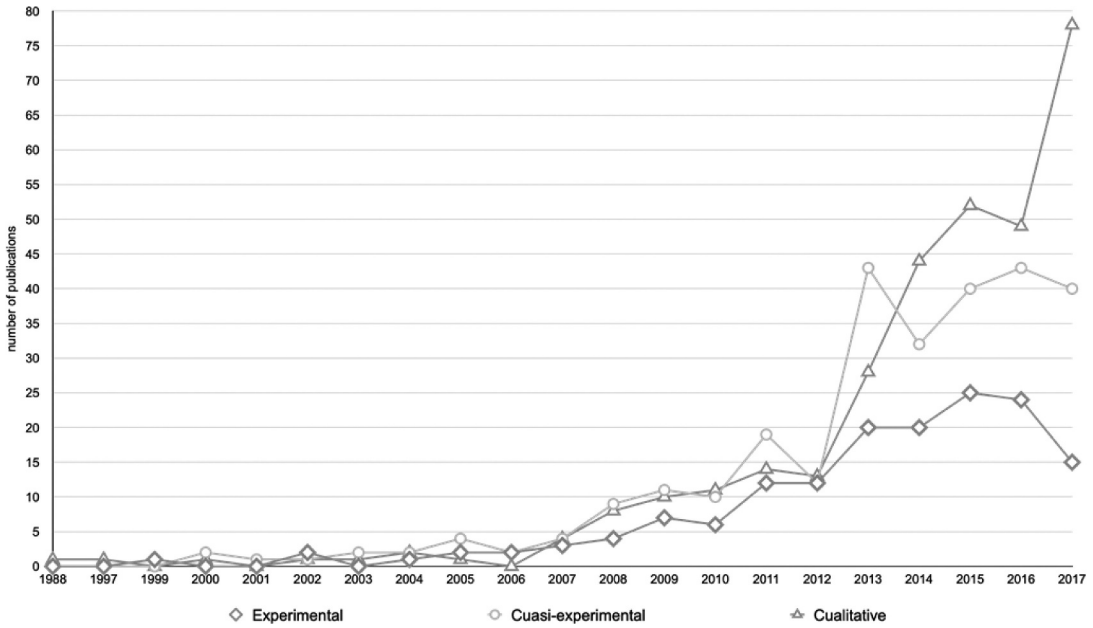

Figure 5. Curve of publications on technology-based treatments based on experimental design.

The main area of knowledge that this type of publication deals with is psychology (n = 251; 33.8%) followed by medicine (n = 110; 14.8%), and engineering (n = 58; 7.8%). The types of ICT employed in psychology to the greatest extent in publications were web-based interventions (n = 94; 37.5%) and cell phones (n = 84; 34.3%). Medicine used web-based interventions (n = 52; 47.3%) and cell phones (n = 31; 28.2%) the most. In engineering, studies published used web-based interventions (n = 21; 36.2%), cell phones (n = 12; 20.7%), and VR (n = 12; 20.7%).

Regarding research method by area of knowledge, the main production in psychology (N = 251) seems to be mainly systematic reviews or meta-analysis (n = 56; 22.3%), quasi-experimental designs (n = 47; 18.7%), and RCT (n = 32; 12.7%). Medicine (N = 110) made most frequent use of RCT (n = 35; 31.8%), systematic reviews or meta-analysis (n = 31; 28.2%), and usability studies (n = 14; 12.7%). In engineering (N = 58), RCT (n = 18; 31%), pilot studies (n = 9; 15.5%), and quasi-experimental studies (n = 7; 12.1%) were the most frequent.

Pearson's x^2 analyses indicated that there was a significant interaction between type of technology and area of knowledge ($x^{245} = 75.749$, $p < .005$), in which the power of association was small ($V = .14$). Specifically, studies on mobile devices were significantly more likely for physiotherapy; studies on robots were significantly more likely for engineering; studies on serious games were significantly more likely for nursing; studies on virtual reality were significantly more likely for physiotherapy and studies on web-based intervention were significantly more likely for medicine.

Furthermore, by area of knowledge, the journals that published psychology most frequently were the *Journal of Medical Internet Research* (n = 26; 10.4%), *BMC Psychiatry* (n = 12; 4.8%), and *Trials* (n = 7; 2.8%). The journals that published medicine most frequently were the *Journal of Medical Internet Research* (n = 20; 18.2%), *BMC Psychiatry* (n = 4; 3.6%), *JMIR mHealth and uHealth* (n = 3; 2.7%), and *PLOS One* (n = 3; 2.7%). In engineering, they were *Journal of Medical Internet Research* (n = 6; 10.3%) and *BMC Psychiatry* (n = 3; 5.2%).

Discussion

This study is a contribution to the bibliometric literature in the area of psychology. Its purpose was to find out exactly what chronological progress has been made in the application of the ICTs to psychology, the characteristics of the populations, and the impact journals that are covering publications. The discussions of the results have been structured according to the research questions outlined in the introduction.

RQ1. Evolution of publications on psychological intervention through ICT

For the last years, since 2007 a growing trend has been observed in publications related to psychology and the use of the ICTs, showing the greatest increase in these publications in 2013 and tending to stabilize in the last 3 years. Similarly, these changes are observed in studies on social media in psychology, in which the increase occurs in 2011.[55] While publications in psychology in all fields have increased since 2003.[54] It is therefore a recent area of research in the stage of expansion of knowledge. This is also observable in the chronological trend of publications by type of research, in which qualitative studies, that is, theoretical, protocols, or systematic reviews, exceed the number of experimental (RCT) and quasi-experimental studies (correlational, case studies, usability studies, or pilot studies). The progressive increase in quantitative and experimental research is a trend observed in the discipline.[56] However, there is also an increase in the publications of systematic reviews and meta-analysis in psychology.[57]

Similarly, changes in the trend of the objectives or topics of the publications are also observable, at the beginning these are aimed at theoretical revisions directed to non-clinical population or intervention in phobias (i.e., improving exposure therapy). Currently, interventions are aimed at specific disorders or problems, for example, depression or substance abuse. These changes have been generated, while technical advances, now ICT is more affordable, offer greater versatility and the

development of software and hardware is greater. If this trend continues, it may be expected for publications in the coming years to focus on the use of mobile devices that provide more versatility for implementing psychological interventions.[8,9]

When comparing initial and current publications we found several differences. For example, the first intervention study using VR consisted of a brief intervention for traumatic brain injury with non-immersive VR techniques.[58] A short time after, immersive VR techniques began to be used for fear[59] or eating disorders.[60] However, technological developments in both hardware and software today are remarkable. Regarding hardware, the first VR glasses used LCD (Liquid Crystal Display) screens, while nowadays glasses include high-resolution color micro-displays with sensors.[61] In the beginning, studies with mobile devices made use of mobile phones as a tool to play therapeutic content (video, audio, etc.),[62] but currently, specific software is being developed for smartphones (Apps).[63] Likewise, the web-based intervention has also improved; at the beginning, the resources and tools were based on interactive diagrams or texts[64,65] but nowadays they also include multimedia content and exercises.[66] As for the use of robots and serious games, the changes are mainly focused on the functionalities that are being developed at the same time as the technical developments. Nevertheless, one point already mentioned by Freeman et al.,[13] is that the efficacy of the intervention will depend more on the validity of the contents and strategies of the intervention than on the type of ICT employed.

RQ2. Research by type of technology and sample population

This bibliometric study has enabled us to find out which ICTs are employed the most often and what type of population they are mainly used for. The results show that websites, online, and/or self-applied interventions are used the most. However, publications making use of mobile devices were published more frequently in the last 3 years. These results are consistent with the global production in mHealth publications that shows the largest increase in 2012 and remains thereafter.[67] We hypothesize that in the coming years, mobile devices will be employed for psychological and health intervention more frequently. Most of the publications were on intervention in adult populations, and less frequently for children and adolescents and geriatric, a point that has already been mentioned in previous studies finding that the use of ICTs in children and youth psychology to be a potential niche for research,[24,68] more so considering how the use of ICTs can motivate this population.[31] The results of this study show significantly different types of technology employed depending on the population. For adults and youth, the ICTs most used were Web-based interventions and mobile devices, while for children virtual reality and robotics were used more often.

Of the psychological disorders or illnesses subject to intervention, depression was the most prevalent disorder, followed by substance abuse and general mental health. Intervention for depression was mainly implemented on websites. However, for intervention in substance use, mental health, and eating disorders, mobile devices were used more frequently. VR was used more often for intervention in ASD and pain. The application of robots was concentrated mainly on intervention for ASD.

RQ3. Bibliometric analysis of journals

Finally, we found many JCR journals publishing studies related to the objective of this study, showing that publications are not concentrated in a series of specialized thematic journals but are accepted by the editorial lines of journals in general. Although some journals specialize in this scientific area, they make up less than 15% of the total. This result is consistent with the number of journals that publish meta-analysis in psychology. Although there is some variability in the journals that publish studies on this topic, the journals that they publish most frequently are high-impact journals that are located within the first two quartiles.

RQ4. Research methods

This study has a series of methodological limitations. In the first place, only those studies published in JCR journals were collected, which leaves out all the rest of the published resources. However, this was considered an indication of quality.[69,70]

Nevertheless, future research on this topic should be considered. The importance of evidence-based treatments in psychology is evident,[71,72] it is necessary to investigate the processes and therapeutic effectiveness. The use of technology has not yet been explored as an evidence-based intervention, although guides are beginning to be carried out exploring the value of health care.[73, 74]

RQ5. Countries and area of knowledge

Most of the studies were done in the USA and the UK, which coincides with the number of publications on general psychology [74] and social media studies.[55] The areas of knowledge published most frequently concerning the use of ICTs were psychology, followed by medicine and engineering.

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Conclusions

Most of the initial hypotheses have been confirmed, except in the case of research designs. This study shows that the publications related to the use of ICT and psychology are an innovative field of study that has been growing for the last 10 years, are in evolution and changes with technological advances. This research is being increasingly specific to clinical diagnosis and mainly with adults. Although there is some specific journal to the research topic, we found a wide variety of journals that publish with this topic, all of them are impact journals within the first two quartiles. Most of the studies are RCT, although we find a greater number of qualitative or quasi-experimental studies, so it is necessary to increase the number of studies with experimental design. Finally, the USA was the country with the most scientific production in all the ICTs.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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Appendix A. Search string

Theme: (psychol*) AND Theme: (intervention) AND Theme: (app)
Theme: (psychol*) AND Theme: (intervention) AND Theme: (augmented reality)
Theme: (psychol*) AND Theme: (intervention) AND Theme: (robot*)
Theme: (psychol*) AND Theme: (intervention) AND Theme: (virtual reality)
Theme: (psychol*) AND Theme: (intervention) AND Theme: (mobile)
Theme: (psychol*) AND Theme: (intervention) AND Theme: (web)

APPENDIX B. Data extraction

VARIABLE	CATEGORIES	DESCRIPTION	CODE
Kind of technology	Mobile	If the article used procedures that involved the use of mobile phones, tablets or other mobile devices in at least one of its components.	M
	Robots	If the intervention or treatment includes the use of social robots in at least one of its components.	R
	Serious games	If the intervention or treatment is done through software in a serious game format, that is, games with specific objectives for psychological treatment or health in at least one of its components.	SG
	Virtual reality	If the intervention includes the use of virtual reality/augmented reality in at least one of its components in at least one of its components.	VR
	Web-based interventions	Interventions applied through the internet in at least one of its components in at least one of its components.	W
	Technology	Studies that are not one technology specific or combine ITC solutions.	T
Topic	Topic/Diagnosis	The topic of the study was indicated. In case of being oriented to a specific psychological disorder or illness, it was codified. The topic of the study was also codified if he objective was improving well-being, assessment, aspects of work or neuropsychological, etc., that is, without psychological disorder or illness. In case of not being oriented to a specific problem or to a non-clinical sample, it was specified. This data was extracted from the participant section or the study objective.	-
Population	Children	If in the participants section an average age = <16 was indicated	C
	Youth	If in the participants section an average age between 17 and 20 was indicated	Y
	Young adults	If in the participants section an average age between 21 and 30 was indicated	YA
	Adults	If in the participants section an average age >30 was indicated	A
	Geriatric	If in the participants section an average age >65 was indicated	GER
	Non-specified	It was classified in this code if the participants' section does not indicate the average age or are studies in which they do not employ participants (for example, theoretical articles or systematic reviews)	NO/ GEN

(*Continued*)

(Continued).

Research method	Assessment	It was classified in this code if the objective of the study was to validate an evaluation procedure through ICT	ASSESS
	Correlational studies	It was classified in this code if the objective of the study is to explore the relationships between two or more variables, or in which the independent variable cannot be manipulated, that is, ex post facto studies	CORR
	Studies of software design or development	It was classified in this code if the objective of the study is to describe the development of the shoftware	D
	Protocol studies	It was classified in this code if the objective of the study is to describe the study design or protocol	P
	Pilot studies	It was classified in this code if the objective of the study is to assess the reliability of the intervention in a pilot study. It was classified in this category if indicated in the title of the article or in experimental design section	PI
	Theory studies	It was classified in this code if the study does not present quantitative data, that is, if a theoretical contribution or critical analysis is made	T
	Quasi-experimental design	It was classified in this code if the objective of the study is to assess an intervention using a pre-post design but it is not possible to randomize the sample or have a control group	Q
	Qualitative desig	It was classified in this code if the study does not present quantitative data, if it is an observational study or in the title of the study either in the design section has been classified as a qualitative design.	QUA
	Systematic review and meta-analysis	It was classified in this code if the objective of the study is to perform a systematic review of the literature or a meta-analysis.	R
	Randomized controlled trials (RCT)	It was classified in this code if the objective of the study is to assess an intervention using a pre-post design with randomization.	RCT
	Studies of usability or ergonomics	It was classified in this code if the objective of the study was to analyze the usability or accessibility of the technology.	U
Year	Year of publication	It was extracted from the year of study publication	-
Journal	journal of publication	It was extracted from the journal in which the study was published	-
Country	County	It was extracted from the county of the first author	-
Area of Knowledge	Area of Knowledge	It was extractor from the department or place of work of the first author	-