Mobile-based collaborative interventions between target participants and circle participants

Joab Cavalcante da Silva
joab@uems.br
Universidade Estadual de Mato Grosso do Sul
Naviraí, MS

Laurentino Augusto Dantas
augusto.dantas.br@gmail.com
Instituto Federal de Mato Grosso do Sul
Naviraí, MS

Marina Ariane D. Di Marzo
marinadimarzo@usp.br
ICMC-USP
São Carlos, SP

Kamila Rios Rodrigues
kamila.rios@gmail.com
Universidade de São Paulo
São Carlos, SP

Maria da Graça C. Pimentel
mgp@icmc.usp.br
Universidade de São Paulo
São Carlos, SP

ABSTRACT

The literature registers the use of mobile devices in interventions that gather information from individual participants within their natural environments. Researchers have identified a need for supporting interventions that involve both participants and individuals within their social circles. To address this need, we conducted a Rapid Systematic Review focused on the following questions: Which papers describe models that enable experts to foster collaboration among group members in interventions mediated by mobile devices or IoT? Which studies present operations related to communication, cooperation, or coordination? How were these solutions developed and evaluated? What roles do participants assume within the interventions? In which domains were these evaluations conducted? The review selected 26 works, most within the domains of Education, Health, or both (84%). The analysis revealed significant gaps in the literature regarding systems and models that facilitate communication, cooperation, or coordination among intervention participants and their social circles. This analysis indicated the need for a set of functional and non-functional requirements to guide the design and evaluation of future solutions. We contribute by proposing these requirements to address the identified gaps and enhance the development of effective intervention systems.

KEYWORDS

Intervention, Mobile, Collaboration, Rapid System Revision.

1 INTRODUCTION

When discussing some computer science issues in ubiquitous computing, visionary Weiser [61] advocated that *"Applications are of course the whole point of ubiquitous computing"* and added, as examples of applications, locating people and shared drawing. The former included examples aimed at facilitating communication and awareness of people's activities. The later emphasized the need for transparent tools for collaboration. Overall, Weiser [61] advocated a shift in computer science research and development: *"away from the machine and back to the person and his or her life in the world of work, play and home."*

Professionals and researchers from areas such as Health and Education work with the concept of *intervention* as the "act of interfering with something in order to influence its development". Support to interventions by computational solutions demands investigations, among others, of problems associated with employing mobile devices in planning and conducting interventions [17, 27].

To inquire into the use of the term intervention in mobile computing research, we examined the Association for Computing Machinery (ACM) Digital Library considering papers published by ACM (ACM-pub) and by other publishers as indexed in the ACM Guide to Computing Literature (ACM-all). We conducted two searches on September of 2023 for papers simultaneously containing the terms intervention and mobile. The first search was restricted to the titles and the second search to abstracts of the papers. For the search restricted to paper titles, we identified 79 articles in ACM-pub and 145 articles in ACM-all. For the search restricted to paper abstracts, we identified 607 papers in ACM-pub and 1658 papers in ACM-all. Our inspection also shows this is a present-day theme evidenced by the fact that, among the 79 papers in ACM-pub and the 145 papers in ACM-all for the search restricted to the paper titles, 39 and 72 articles (49.4% and 49.7%), respectively, were published in the last five years. Moreover, for the search restricted to the abstracts, 266 and 732 (43.8% and 44.1%) papers were published in the last five years among the 607 results in the ACM-pub and the 1658 ACM-all.

Intervention-based mobile computing research employ variations of the Experience Sampling Method (ESM) [11, 12, 29, 30] or its descendants, the Ecological Momentary Assessment (EMA) [53] and the Just-in-Time Adaptive Interventions (JITAI) [59] to gather information from target participants in their natural environments [9, 23, 36]. Examples include studies [5, 28, 39, 48, 62] that employed the LifeData [31], the movisensXS [35], or the Mobile EMA [24] systems. In particular, JITAI-based personalized interventions demand contextual data and self-reported responses [22, 37, 59], as in context-aware sampling [18, 25] and handling interruptions [27].

Surveying research involving mobile device-based interventions based on ESM, van Berkel et al. [57] reviewed 65 papers reporting specialist-participant interventions, observing the opportunity

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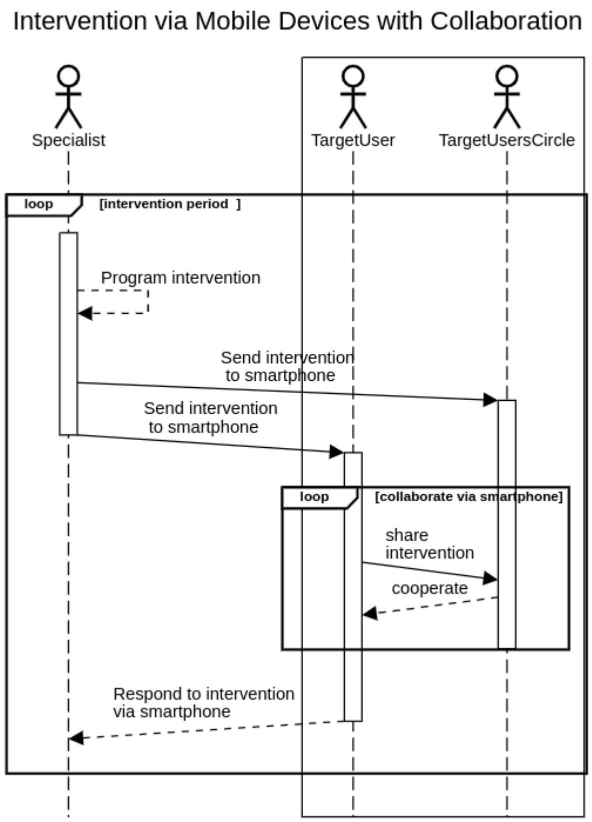

Figure 1: Specialist uses mobile devices to perform (remote) interventions demanding collaboration between target participants and participants in their circle.

for engaging user's social networks to provide context-related information. van Berkel et al. [58] also register the need improving accuracy in human-labled data. Specifically regarding the social context of target participants, Cunha et al. [13] identified the demand for support for interventions that affect not only the target participant but also people in their circle, as proposed and evaluated, using a specialist to encourage collaboration, in the design documented by Zaine et al. [63]. Thus, in interventions reaching target participants in a natural environment via mobile devices, there is a demand for supporting interventions that also involve people from the participant's circle, as illustrated in Figure 1.

In the scenario of Figure 1, a specialist (eg. Health professional) develops and applies, via mobile devices, an intervention that involves the target participant (eg. patient) and people in their circle (eg. family members). This scenario demands efforts to identify, in the computing literature, models or applications that combine interventions, remote or not, and collaboration operations between target participants and members of their circle. *Such efforts are relevant to the Brazilian Symposium on Multimedia and the Web, as the symposium includes, among its areas of interest, Mobile and Wearable Computing, and Ubiquitous and Pervasive Computing.*

We conducted a rapid systematic review (RSR) to identify relevant works on the problem in an objective and reproducible manner [45]. This study followed the best practices for RSR outlined by Featherstone et al. [16] and began with the development of a PRISMA-P protocol [46] to specify the steps and outcomes anticipated in the research.[1]

We classify the work as a Rapid Systematic Review because we used the indexing of the ACM Digital Library to access multiple publishers in the field of computing. Additionally, during the selection and inclusion phases, the workload was divided into two groups, each with a pair of reviewers.

The paper selection stage employed pairs of reviewers and an online collaborative tool to support systematic reviews. To reduce the risk of bias associated with the reviewers' experience, members of each pair had complementary experience.

In the remainder of this paper, Section 2 summarizes the review protocol, Sections 3 and 4 present the answers to the research questions and the synthesis of the selected works, respectively. Section 5 discusses the identified requirements and Section 6 presents our final remarks.

2 REVIEW PROTOCOL

In the analysis of the studies, contributions that involved models explicitly or implicitly were selected, in the second case considering the model associated with the design of systems and applications. Therefore, the consultation involved studies that included models, frameworks, architectures, infrastructures or systems. On the other hand, the concept of collaboration observed during the analysis of the studies is the one identified in the groupware literature as it involves activities of coordination, communication and cooperation [15] [19]. Still, for the scope of computational support for interventions, studies associated with the use of smartphones, Internet of Things (IoT), wearable or mobile devices were considered. Furthermore, considering that the words necessary for the study are common and frequently used in academic texts, the analysis was restricted to complete works that contained the keywords defined in the abstract or title. Finally, the scope of intervention was sought through studies also involving mediation.

The protocol explained the objective of answering research questions that were elaborated according to the PICO approach (Participants, Interventions, Comparators, and Outcomes) [47]. It is important to note that the term intervention, in the case of a systematic review, corresponds to the innovation investigated by the research reported in the article analyzed.

2.1 Objectives and Research Questions

The review sought answers for:

(1) Which papers report models that allow an specialist to promote collaboration among group members in the scope of an intervention mediated by mobile devices or IoT?
(2) Which articles offer communication, cooperation, or coordination operations?
(3) How were solutions developed and evaluated?
(4) What roles do participants in the intervention assume?
(5) Which domains were used for evaluation?

[1] http://www.prisma-statement.org/Extensions/Protocols

2.2 Eligibility Criteria (PICO)

- **Population (P)**
  - Studies report models that allow an specialist to promote collaboration between members of a group in the scope of an intervention mediated by mobile devices or IoT;
- **Invervention (I)**
  - Specialist promotes collaboration between group members in the scope of intervention;
  - Operations are presented explicitly or implicitly;
- **Comparison(C)**
  - Explicit interventions proposed by specialists for groups of participants
  - Explicit collaboration between group members in the scope of interventions
  - Explicit collaboration model used
  - Explicit operations for communication, cooperation or coordination
  - Explicit roles and their responsibilities
  - Explicit groups and their members
  - Preferably, it explicit evaluations carried out
  - Preferably, it explicit the devices used
  - Preferably, it explicit the notifications used;
- **Outcome (O)**
  - main: collaboration operations, assessment
  - additional: role, type, domain, design.

2.3 Sources

- The consultation was carried out in the ACM Digital Library database, with selection of the ACM Guide to Computing Literature service. This service encompasses works carried out within the scope of research in computing as categorized by the ACM itself, and are published by the ACM or are available in other digital libraries.
- At the time of publication of this paper (accessed on August 25, 2024), the ACM Full-Text Collection includes 754,627 records, which is approximately 20.1% of the total 3,748,046 records in the ACM Guide to Computing Literature.
- The search was restricted to the abstract and title of articles.
- We then applied the filter *Research Articles*.

2.4 Search strategy

Consultations were carried out between 01/09/2023 and 20/09/2023[2] and resulted in 359 articles. The search strings were as follows:

(1) "**query**": Abstract:(mobil* OR smartphon* OR wearabl* OR IoT) AND Abstract:(model* OR framework* OR architectur* OR infrastructur* OR system*) AND Abstract:(communicati* OR notificati* OR collaborati* OR cooperat* OR group*) AND Abstract:(intervent* OR mediati*) "**filter**": Article Type: Research Article
(2) "**query**": Title:(model*) AND Title:(group* OR collab*) AND Abstract:(group* OR collab*) AND Fulltext:((intervention or mediation)) "**filter**": Article Type: Research Article

The corresponding URLs are:[3]

- https://dl.acm.org/action/doSearch?fillQuickSearch=false&ContentItemType=research-article&expand=all&AllField=Title%3A%28model*%29+AND+Title%3A%28group*+OR+collab*%29+AND+Abstract%3A%28group*+OR+collab*%29+AND+Fulltext%3A%28%28intervention+or+mediation%29%29
- https://dl.acm.org/action/doSearch?fillQuickSearch=false&ContentItemType=research-article&expand=all&AllField=Abstract%3A%28mobil*+OR+smartphon*+OR+wearabl*+OR+IoT%29+AND+Abstract%3A%28model*+OR+framework*+OR+architectur*+OR+infrastructur*+OR+system*%29+AND+Abstract%3A%28communicati*+OR+notificati*+OR+collaborati*+OR+cooperat*+OR+group*%29+AND+Abstract%3A%28intervent*+OR+mediati*%29

2.5 Data management

The selection and analysis of articles were conducted using Rayyan, an open and free online collaborative tool designed for systematic reviews. Rayyan offers a blind mode feature, enabling reviewers to analyze articles independently without access to the assessments of their peers.[4]

2.6 Selection Process

After removing 23 duplicate works, the total considered was 336 articles. There was no restriction on the publication period of articles. In the analysis phase, works that did not correspond to full research articles were also disregarded. A summary of the process is presented in Figure 2.

- To verify compliance with the eligibility criteria, the first phase of selection of articles, corresponding to the reading of titles and abstracts, was carried out collaboratively by four researchers (authors of this study) using Rayyan in blind mode. This analysis was divided and developed in pairs: each pair evaluated approximately 50% of the total articles;
- Once the analysis was completed in blind mode, it was deactivated so that everyone could be aware of the evaluation of other pair. The disagreements that occurred between the members of one pair were decided by the other pair. The remaining differences were decided on a case-by-case basis by the team. From a total of 336 articles analyzed, this step identified that 68 articles met the eligibility criteria;
- The synthesis stage involved the complete reading of the 68 articles to select those that met the eligibility criteria. This step was carried out collaboratively by two of the authors and, as a result, 26 works were selected.

Of the 26 selected articles, we processed the results and identified that 17 (65%) were published by ACM, 4 (four) by Science Direct-Elsevier, 3 (three) by IEEE, 1 (one) by Springer-Verlag, and 1 (one) by Taylor & Francis Group.

Figure 3 shows the distribution of selected articles with their respective years of publication.

[2]This study is an update of research conducted in 2021 and described by Silva [50]. All the values presented in this work refer to the updated data obtained in 2023.

[3]The number of records retrieved at the time of publication (August 25, 2024) is 378.
[4]https://rayyan.ai

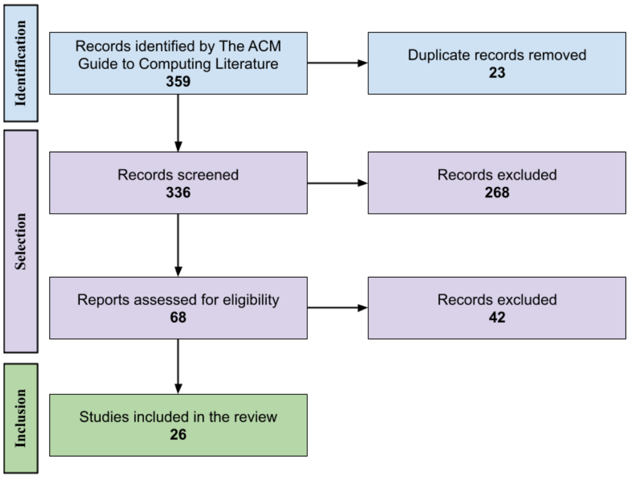

Figure 2: PRISMA flow summarizing the selection process.

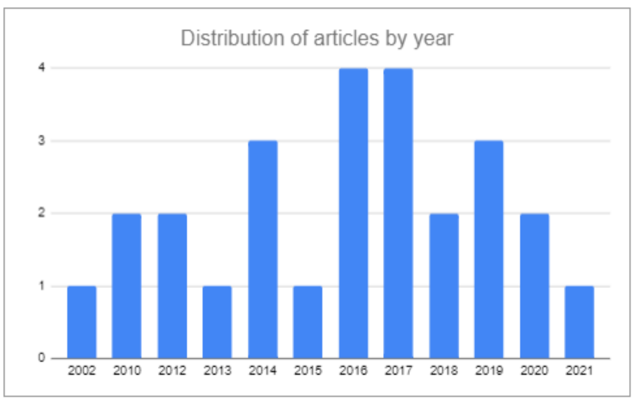

Figure 3: The 26 selected articles by year of publication.

2.7 Bias Risk and Actions

Regarding the results reported in the articles, the main bias is associated with the initial and exploratory stage of most studies, which usually reported qualitative assessment.

In the bias associated with carrying out the RSR, the main risks and the actions taken to minimize them were:

(1) The research was restricted to works classified in the computing area by the ACM Digital Library. Actions were not taken in this case because it was considered that the main vehicles are indexed;
(2) The search strings restricted the search to title and abstract fields for terms commonly used in computer texts, we only included full research articles. Attitudes were not taken because it was considered that the most relevant works were identified;
(3) The distinct experience of the 4 evaluators. To lessen the risk of associated bias, pairs were set up so that their members had complementary experience.

3 ANSWERS TO RESEARCH QUESTIONS

This section summarizes the answers to the research questions, obtained from the analysis of the 26 articles selected.

3.1 Which papers report models that allow an specialist to promote collaboration between members of a group in the scope of an intervention mediated by mobile devices or IoT?

Two studies proposed a theoretical model and discussed its conceptual application [51] [66]. One of the study presents a list of design problems, challenges, and opportunities drawn from qualitative research [32]. In the other studies, the validations presented are in the form of a simulation or a projected, developed or evaluated system (qualitatively or quantitatively).

It is important to note that the selection phase did not include studies referencing the term IoT.

Table 1 summarizes that, among the 26 papers analyzed, five (5) papers proposed a model, but they do not have associated implementation or evaluation. Furthermore, seven (7) works propose a model and present associated implementation. Also, ten (10) works do not propose a model, but an implementation associated with an existing model: among these, 7 (seven) detail the modeling of the system, and 8 (eight) present an evaluation with users. Finally, 5 (five) papers proposed a model, developed an associated system and evaluated the system qualitatively or quantitatively.

3.2 Which papers offer communication, cooperation or coordination operations?

Among the 26 studies analyzed (Table 1), not all made explicit the use of cooperation, communication and coordination operations.

Communication is an essential aspect in interventions, and it occurs indirectly in two of the cases where communication is not made explicit (via implicitly captured data analysis).

3.3 How were the solutions developed and evaluated?

Table 1 also indicates what type of design was adopted for the development of the work. Most of the works used case study (12) or brainstorm (8). In two cases, the research involved the development of a digital solution for an existing activity (game [40] and business process [33]).

As summarized in the last column of Table 1, the validation reported in the work, if any, used in most cases qualitative techniques that involved target users. In one case, given the preliminary stage of the work, instead of target users (autistic children) the study was carried out with children without disabilities [45]. In the case of a business process solution involving currency, the authors performed a simulation that used a different time scale (5 days instead of 5 months), and used a digital and simulated version of the currency [35].

Table 1: Models: proposal (Mp). System: proposal (Sp) and evaluation (Se). Operations: Cooperation (Cp), Communication (Cm) and Coordination (Cd). Design (Ds) and Evaluation (Ev) Strategies.

Ref	Mp	Sp	Se*	Cp	Cd	Cm	Ds**	Ev
Samonte et al. [44]	0	1	0	1	1	1	Bs	Functionality testing/Acceptance testing without involving target users
Thalheimer et al. [54]	**1**	**0**	**0**	0	1	1	EC	Simulation
Gong and Liu [20]	1	1	1	1	1	1	EC	Pre/post-test, 6 participants (*improved grades*)
Mehmood et al. [33]	0	1	1	1	1	1	RD En Pr	Simulation (1month=1day, 3 groups*x*5 people)
Marcu et al. [32]	**1**	**0**	**0**	1	0	1	En	List of problems, challenges, and design opportunities
Song et al. [52]	0	1	1	1	1	1	Bs	Monitoring (12 families x 4 weeks)
Zheng and Motti [65]	0	1	1	1	1	1	Bs	Qualitative, 58 participants
Alam et al. [1]	1	1	0	1	0	1	Bs	Pilot
Davidson et al. [14]	0	1	1	1	0	1	EC	36 walnut-allergic teenagers improved their self-management level
Salleh et al. [43]	1	1	0	1	0	1	EC	Functionality test/Acceptance test
Torres et al. [56]	1	1	1	1	0	0	EC	14 healthy elderly and 26 hospitalized elderly tested and indicated efficacy
Palomo-Duarte et al. [40]	0	1	1	1	0	1	EC	Qualitative, 3 patients indicated efficacy
Risso et al. [42]	1	1	1	1	1	1	EC	12 participants tested (posture correction), satisfactory results
Shin et al. [47]	1	1	1	1	1	1	Bs	Pilot, 21 children x 10 months, behavior improvements
Zakaria et al. [64]	1	1	1	1	1	1	RD	Piloto, group of 6 students, 55min session
Mohr et al. [34]	0	1	1	1	0	1	EC	8 participants for 4 weeks
Coskunçay and Çakir [10]	**1**	**0**	**0**	1	1	1	Pa	Analysis of the CSCBPM process***
Kaushik et al. [26]	1	1	0	1	0	0	EC	Prototype
Tiwari and Sorathia [55]	1	1	0	1	0	0	Bs	Qualitative, 8 participants highlighted the importance of the visual design
Arciniegas et al. [2]	0	1	1	1	0	1	EC	30 participants, pre/post-tete, recordings confirm potential
Haque et al. [21]	0	1	1	1	1	1	Bs	Pilot study with 43 patients who approved the system/treatment
Solomon et al. [51]	**1**	**0**	**0**	1	1	1	EC	Discussion of the application of the theoretical model in a scenario
Ramach et al. [41]	1	1	0	1	1	1	En Vs	7 participants, 8 weeks, qualitative: improved engagement
Zhu et al. [66]	**1**	**0**	**0**	1	0	1	Bs	Discussion of the application of the theoretical model in two scenarios
Avouris et al. [4]	1	1	0	1	0	1	EC	Qualitative: communication improvements
Wang et al. [60]	1	1	1	0	1	1	EC	Simulation
total	15	20	13	24	13	23		

** *Brainstorm (Bs) Case Study (EC) Interview (En) Prototype (Pr) Participatory (Pa) Design Reuse (RD) Visit (Vs)*
* **1-0-0**: no associated implementation *** *Computer Supported Collaborative Business Process Modeling (CSCBPM)*

3.4 Which domains were used and what roles did the participants assume?

Table 2 summarizes, for the 26 studies, in which domains the interventions were carried out, and the roles of the participants. Most works involved the domains of Health, Education, or both (84%). In preparing the interventions, users had roles of specialists in the domain (e.g. teacher or psychologist) or their assistants (e.g. monitor, in the case of Education, or professional assistant, in the case of Health). Target participants were students (e.g. children, adolescents, elderly, adults), with or without cognitive (e.g. autism), health (e.g. allergy), motor (e.g. fall risk), members of financial associations or designers. Most studies carried out some type of evaluation, usually qualitative, with positive results.

4 SYNTHESIS OF SELECTED WORKS

We present a summary of each study work, in the order of the tables, focusing on the eligibility criteria of the RSR.

Samonte et al. [44] present an intervention-based mobile app for improving communication skills learning for autistic children in the Philippines. Children who have difficulty communicating with others are often unable to express even their basic needs and desires, and change their moods easily. In this system, the therapist is able

Table 2: Domains and roles involved in the interventions reported in the works (prof: professional)

Ref	Domain	Roles
Samonte et al. [44]	Special Education	user-education prof-education
Thalheimer et al. [54]	Distance Education	user-education support-education
Gong and Liu [20]	Education	user-education prof-education
Mehmood et al. [33]	Business Finance	finance association leaders and members
Marcu et al. [32]	Behavioral Education	user-education support-education (parents, children, school)
Song et al. [52]	Child Health	health support (father, mother, third person)
Zheng and Motti [65]	Special Education	Special Students, Supporters, Teachers
Alam et al. [1]	Home Health	user-health support-health
Davidson et al. [14]	Food Education	User Health
Salleh et al. [43]	Special Education	user-education support-education prof-education support-general (child, supporter, researcher, robot)
Torres et al. [56]	Elderly Health	user-health support-health
Palomo-Duarte et al. [40]	Health	user-health support-health prof-health
Risso et al. [42]	Health	user-health support-health
Shin et al. [47]	Special Education	User Education
Zakaria et al. [64]	Education	user-education prof-education
Mohr et al. [34]	Mental Health	prof-health user-health
Coskunçay and Çakir [10]	Business	team members
Kaushik et al. [26]	Health	user-health prof-health doctor-health support-health
Tiwari and Sorathia [55]	Health	prof-health user-health
Arciniegas et al. [2]	Environmental Science	environmental science professionals
Haque et al. [21]	Health	user-health prof-health doctor-health
Solomon et al. [51]	Health	patient care
Ramach et al. [41]	Maternal Health	user-health support-health
Zhu et al. [66]	Design	design teams
Avouris et al. [4]	Education	user-education support-education
Wang et al. [60]	Education	user-education prof-education

to follow the development of the child's activities. The system, qualitatively tested by specialists and parents of children without disabilities, had positive results.

Zheng and Motti [65] present WELI (Wearable Live), an application designed to help young adults with intellectual disabilities. The app helps students in activities that require behavioral and emotional skills and involve collaboration. WELI features include behavioral intervention, mood regulation, reminders, checklists, surveys and rewards. The system allows for immediate interventions to remind students to focus and also to mediate their participation in class. The app was evaluated with 58 participants (21 special students and 37 supporters). The results showed enthusiasm from the students and revealed several criteria to be observed when designing applications for this audience.

Salleh et al. [43] used an intervention framework that uses a humanoid robot to interact with a child. The study involved collaboration between a researcher who defined the interventions, a child who received voice messages and interacted with the robot, and a caregiver who monitored the results of the interventions. The analysis identified requirements for an interventional model to alleviate the burden of discomfort for children and supporters, to be used in the future with autistic children.

A recurring problem in courses offered at a distance is the high rate of dropouts and students' lack of motivation. **Thalheimer et al. [54]** present an architecture based on agents that interact with each other to make virtual learning environments more attractive, interactive and adaptable to student profiles and preferences. The work presents a generic model, with data collection, tracking agent function model, agent-agent communication and adopted methodological procedure. Mediating agents carry out communication and cooperation operations in the collaboration process. From the analysis of log information, the system triggers predefined triggers (e.g., when a student does not access a subject for a certain time, the system notifies the agent for predefined intervention). The architecture was evaluated through simulation with data from the Moodle environment.

Gong and Liu [20] present an intervention model based on learning analysis in an environment that explores big data analysis techniques. The model was evaluated in an educational setting, at a distance, and proved to be useful to improve academic performance, especially for at-risk students. The model has four modules:

(1) data collection (obtaining student information),
(2) data processing (analysis of collected data, identification of risks, profile and performance),
(3) Intervention implementation (different types of intervention: individual, group, class, recommendation, immediate, scheduled, feedback),

(4) evaluation (analysis of intervention effectiveness, based on student performance, interest and attitudes).

Rotating Savings and Credit Association (ROSCA) is a community collaborative lending strategy established decades ago [3], high-impact [6] and current (eg [38]). **Mehmood et al. [33]** present the design and evaluation of an Android application developed as a digital version of ROSCA. After detailing interviews carried out with 80 users to understand the use of the original version, recorded using paper, the authors present and justify the application's design. The reported evaluation simulates 3 groups performing a ROSCA-type intervention, adapting the time from 5 months to 5 days, during which the participants used the *mobile* application in their natural environment.

In the educational domain, **Marcu et al. [32]** carried out a qualitative study of the process of interventions related to behavioral problems to identify gaps in the collaboration between actors in the school environment and the family. Instead of an abstract model, the work contributes to the identification of barriers and challenges faced by actors in sharing student behavioral information. The research observes that, in the school-home scope, behavioral interventions are hampered by failures to share information; that the practice of documenting and monitoring behavior in schools varies greatly; and that school records are used primarily for internal use. The research explains that it is necessary to expand communication with parents to engage them in a behavioral intervention plan for their children; that clear tools and processes for bidirectional information sharing are lacking, which reveals an impediment to collaboration. The authors highlight the potential of communication technologies, in particular mobile devices, for implementing solutions.

BebeCODE is the system *mobile* collaborative child development tracking proposed by **Song et al. [52]**. The system collects information separately from the father and the mother in relation to the baby's development, aiming to identify and resolve any disagreements through images or insertion of a third person. The study evaluated the monitoring of 12 families for 4 weeks and recorded 22% of disagreement between the parents' views. Parents reported better awareness of their child's development with the proposed system.

On the other hand, **Alam et al. [1]** proposed *BESI* as an infrastructure for sensing and behavioral (and environmental) intervention to detect the need for intervention by caregivers in the home environment. *BESI* detects behavioral activities via wearable devices and environmental sensors that communicate with a local server and, when necessary, send notifications to caregivers. The system was used in a real environment, in two homes, each with a patient-caregiver pair. The results were used to evolve the system in two phases. The evaluation registered results considered positive.

Risso et al. [42] present a system based on cloud computing and mobile devices (*Cloud-based Mobile System*) for monitoring and treating respiratory diseases at home, aiming to improve the quality of life of patients and their caregivers. The structure uses sensors that capture the patient's vital signs and communicate with the *smartphone* application, and this with the hospital. The system allows patients to have up-to-date information about their health status and notifications are mainly managed by caregivers. Pilot studies in the environment of three patients under typical *homecare* conditions indicated that the system offers greater safety and quality of life for patients and their caregivers.

Anaphylaxis is a sudden, generalized allergic reaction with serious or fatal potential, usually related to food sensitivities. People with these problems often lack the self-awareness to safely manage their needs. **Davidson et al. [14]** designed an educational intervention comprising group discussion on videos of simulated scenarios about sensitivity to ingestion of nuts. This approach was implemented in a mobile application containing anaphylaxis narratives in the form of videos. The authors tested the intervention with 36 nut-allergic adolescents in a one-year follow-up. Participants demonstrated control over their allergies and educational progress on the subject.

To prevent falls in older people, **Torres et al. [56]** feature a hierarchical model to recognize risky situations. The model uses statistical learning resources and predicts situations that can result in a fall. The solution uses wearable sensors on the elderly person's clothing. The sensors are monitored by a system that, upon identifying a risky situation, triggers an alarm for the supervisory team to intervene and prevent a fall.

Shin et al. [47] present a relational model of intervention to promote behavior change. It is a generic system based on three entities: a target user (who needs to change behavior), a helper user (supporting the desired change) and a mobile application. The system monitors the target user and when this acts against the purpose of change, the helper user can intervene causing some uncomfortable situation, and then ask the target user to perform the desired behavior to stop the uncomfortable event. The system, tested with 12 participants in an experiment to change and correct posture, showed the effectiveness of the model and its applicability to other areas.

On the other hand, **Zakaria et al. [64]** developed a proof of concept aimed at helping children with problematic behaviors to improve their behavior without the intervention of caregivers, thus lightening the burden on those responsible. Using wearable devices, the system detects changes in behavior and issues verbal interventions or visual cues on the child's smart watch. Notifications are generated according to studied and structured aspects of behavior. Preliminary assessments indicate that the intervention model can help children to change their behavior and reduce the need for human intervention on the part of those responsible.

In turn, **Mohr et al. [34]** analyze common problems of failure in depression treatments (eg, poor medication adherence, poor doctor-patient communication) and present a mobile-based intervention system to address systematically the points of failure in the treatment. The authors carried out a pilot study with 8 patients, with data collection and instructional interventions, which lasted 4 weeks. The results were positive in terms of medication adherence, well above usual, and the severity of depressive symptoms was significantly reduced.

The concepts of Activity Theory, originated in the field of Psychology [7] and widely used in Human-Computer Interaction research [8] and Collaborative Systems [19], consider that individuals act through technology, rather than interacting with it. Thus, individuals perform actions on objects to achieve a certain goal. **Coskunçay and Çakir [10]** used Activity Theory to examine –

considering levels of activities, actions and operations – human-human and human-computer interactions in the context of collaborative business process modeling supported by computation (*Computer Supported Collaborative Business Process Modeling: CSCBPM*). The analysis examined the CSCBPM process at the Elicitation, Formalization, Validation and Verification levels. The study identified difficulties between the components of the theory, presented how these difficulties were dealt with, and listed suggestions to increase the efficiency of interaction in system designs.

Tiwari and Sorathia [55] present a model of health care intervention in poor and illiterate communities in India, and was evaluated in a case study with pregnant women. The model is implemented in a system that performs interventions on a low-cost mobile device capable of reproducing audio and video content. The system has an interface for healthcare professionals who remotely monitor pregnant women, and an intervention and medical counseling application for pregnant women. The results indicated significant improvements in relation to the traditional assistance existing in the evaluated communities.

Aiming to improve the quality of health of people living in regions with difficult access, **Kaushik et al. [26]** present a conceptual architecture of intervention for health care in communities, and an corresponding *web-mobile* infrastructure. The model involves collaboration between patients, healthcare professionals (who collect data and visit patients), physicians (who diagnose and monitor patients) and partners (technical support). The application of the intervention in a real environment is presented as planned for the next step of the work.

Ramach et al. [41] present an approach to improve maternal health in rural India. In these regions, each village has a local responsible person to assist pregnant women in accessing health services. However, resource limitations discourage these women from performing their duties. The researchers used a set of short videos (less than 1 minute) to persuade women to join the programs, as well as testimonials to motivate local female contributors and encourage local video recording. The solution was used in a pilot study applied with seven professionals, lasting eight weeks, in two phases. The approach resulted in greater motivation and involvement of local supporters and greater adherence to health services.

To support the decision of groups in solving problems related to allocation and land use, **Arciniegas et al. [2]** investigated the effectiveness of using collaborative tools based on maps. The theme involves, among others, political and geographic issues, which demand collaboration. The assessment included tests on the usefulness of the tools, the clarity of information, and the impact on decisions. The researchers found that cognitive effort is diminished when work is done in groups and individual performance achieves greater levels of clarity about the process than individual work. The assessment was carried out with 30 participants using interviews, forms and recordings.

Palomo-Duarte et al. [40] developed an application that reuses a game design designed to support foreign language teaching. The application demands that a group of students make an appointment for other members of the group to do it using an agenda shared with the group and a text chat. The authors designed several features to support the teacher in tracking student engagement and learning. A pilot test was carried out which evaluated the features.

Haque et al. [21] present an interventional system based on mobile computing for monitoring the symptoms of breast cancer patients. Such patients need adaptive *feedback* oriented treatment. The proposed system enables remote data collection, and includes two videos produced to increase patient motivation. The evaluation of the system showed positivity in the treatment of cancer: helping physicians, facilitating necessary interventions, improving communication for decision-making between those involved (physician-patient-attending) and improving the quality of life of patients.

Solomon et al. [51], on the other hand, present a theoretical approach of how to model collaborative work that takes place through social networks. The complexity of this task is great due to the potential for large-scale interaction of social media. The approach was tested with its application in conceptual modeling of the interaction involved in a community focused on supporting the self-care of diabetic patients. The modeling highlighted the need to promote the participants' motivation and commitment to achieve pre-established goals such as: improving their diet, exercise, medication, glucose monitoring and communication with health professionals. Communications between professionals were planned as part of the strategy. The authors argue that approach needs to be evaluated in other domains. In another field,

Zhu et al. [66] presented the *Hive-Mind Space* (HMS) as a model for supporting collaborative design projects and stimulating creativity among design teams. The model, theoretical, describes mediation mechanisms that propose to solve communication problems commonly existing between teams in design projects, enabling teams to reach shared understanding during the processes. The authors validated the model by theoretically applying them to two scenarios. Another tool is the OCAF *framework*, presented by **Avouris et al. [4]** for collaborative problem solving based on dialogs and actions in learning environments. OCAF offers qualitative and quantitative indicators of collaboration and can be applied to face-to-face or remote groups. With the support of a web log analysis tool, *framework* was evaluated in case studies involving remote and face-to-face problem solving.

Wang et al. [60] propose a data-driven approach that integrates psychological insights and knowledge from historical data. This approach allows to optimize the delivery of contextual notifications based on empirical data, even when there is no direct information about user responses to notifications. Furthermore, the approach considers a restriction on the frequency of notifications, aiming to reduce the interaction overload for users.

5 REQUIREMENTS FOR DESIGNING SYSTEMS SUPPORTING MOBILE-BASED COLLABORATIVE INTERVENTIONS

The review revealed gaps in the literature concerning the availability of systems and models that facilitate communication, cooperation, and coordination between intervention participants and their respective support circles. Notably, there is a lack of studies providing systematic and reproducible empirical assessments, as well as systems that enable such assessments.

These findings underscore the need for key requisites that a system must meet to ensure effective intervention and support for interactions involving participants and their support networks. Specifically, both functional and non-functional requirements are essential for systems designed to facilitate communication, cooperation, and coordination among specialists, intervention participants and their support circles.

As summarized in Table 3, these requirements include the ability for the system to facilitate coordination by enabling specialists to design interventions for target populations (TP) and track collaboration between TP and care providers (CP). The system must support communication by allowing specialists to send alerts and interventions to TP and/or CP, enabling TP to provide critical contextual information, and issuing help alerts. Additionally, the system should support cooperation and coordination by allowing real-time remote interventions and enabling CPs to visualize reports for monitoring and decision-making. It is crucial that the system ensures privacy and security of sensitive data, performs well in performance metrics such as response time, is available in offline mode, features a simple and intuitive interface, and offers accessibility features to accommodate all users' needs.

6 FINAL CONSIDERATIONS

The literature indexed by the ACM allowed the realization of a Rapid Systematic Review in an objective and reproducible way. Twenty-six articles that met the eligibility criteria were analyzed and summarized. As a result of the review, it was possible to observe the absence of models, infrastructures and systems that support the use of mobile devices in interventions that involve the collection of information, in a natural environment, from target participants and people in their circle. In the scope of models and systems, a detailed contribution was proposed by Silva [49].

This review identifies the demand for studies that define techniques and computational infrastructure, evaluated in studies involving specialists, target participants and people from their circles. In this sense, a set of requirements was suggested for the development of solutions that support the context under study, that is, requirements for designing systems supporting mobile-based collaborative interventions

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Table 3: Suggested functional and non-functional requirements for collaborative systems (*TP: Target Participant. CP: Circle Participant*)

	Systems should	Requisites
RF1	allow specialists to design interventions for TP that can be followed up by TP	coordination
RF2	allow specialists to send alerts to TP and/or CP	communication
RF3	allow specialists to send interventions to the TP and/or the CP	communication
RF4	allow specialists to track collaboration between TP and CP	coordination
RF5	allow specialists to view data from collaborative interventions between TP and TP	coordination
RF6	allow TP to send important contextual information to TP and/or specialist	communication
RF7	allow TP to access the summary/report of your follow-up	communication
RF8	allow TP to issue help alerts to CP and/or specialist	communication
RF9	allow CP to access TP data	coordination
RF10	allow the CP to carry out remote interventions, in real time, with the TPs	cooperation and coordination
RF11	allow the visualization of reports by the CPs for monitoring and decision making	cooperation and coordination
RF12	enable reciprocal communication between TP and specialist	cooperation and communication
RNF13	ensure privacy	anonymity of collected data
RNF14	ensure the security of sensitive information	security
RNF15	perform well with regard to response time	performance
RNF16	be available in *off line* mode	availability
RNF17	have simple and intuitive interface	usability
RNF18	offer accessibility	accessibility features

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