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Technological innovations in primary care for disaster management: a scoping review

Inovações tecnológicas na atenção primária para a gestão de situações de desastres: revisão de escopo

Innovaciones tecnológicas en la Atención Primaria para la gestión de situaciones de desastres: revisión de alcance

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ABSTRACT

Objective: To analyze the scientific literature on technological innovations implemented in Primary Health Care services to manage disaster situations.

Method: Scoping review following the methodological framework of the Joanna Briggs Institute. It was carried out in November 2024 on the LILACS (VHL), PubMed (NLM/NCBI), Web of Science, CINAHL (Ebsco), EMBASE (Elsevier) and IEEE Xplore databases. Articles related to Primary Health Care, technological innovations and disaster management were included and organized in Rayyan®. Data were analyzed using Bardin's Content Analysis structured into thematic categories.

Results: Out of 832 publications, 58 studies (predominantly from the Americas, 2021-2023) were selected. The analysis highlighted telehealth, artificial intelligence, and smart tools as strategic innovations in Primary Health Care for disaster management. These technologies facilitated care continuity for both disaster-specific needs and other health issues, significantly enhancing accessibility and reducing risk. Nevertheless, persistent challenges include digital inclusion, infrastructure limitations, and balancing technology with human-centered care.

Conclusion: Technological innovations are strategic tools in the continuity of care and to mitigate risks in disasters. However, investments in infrastructure, digital inclusion and sustainable public policies are still needed.

Descriptors: Primary health care. Health management. Disaster preparedness. Health sciences, technology, and innovation management. Biomedical technology.

RESUMO

Objetivo: Analisar a literatura científica acerca das inovações tecnológicas implementadas nos serviços da Atenção Primária à Saúde para a gestão de situações de desastres.

Método: Revisão de escopo seguindo o referencial metodológico de *Joanna Briggs Institute*, realizada em novembro de 2024, nas bases LILACS (BVS), PubMed (NLM/NCBI), Web of Science, CINAHL (Ebsco), EMBASE (Elsevier) e IEEE Xplore. Foram incluídos artigos com relação entre Atenção Primária à Saúde, inovações tecnológicas e gestão de situações de desastres, e organizados no *Rayyan®*.

Resultados: De 832 publicações, foram selecionados 58 estudos (predominantemente das Américas, entre 2021 e 2023). A análise destacou a telessaúde, a inteligência artificial e ferramentas inteligentes como inovações estratégicas na Atenção Primária à Saúde para a gestão de desastres. Essas tecnologias facilitaram a continuidade do cuidado tanto para necessidades específicas de desastres quanto para outros problemas de saúde, ampliando significativamente o acesso e reduzindo riscos. No entanto, permanecem desafios relacionados à inclusão digital, limitações de infraestrutura e ao equilíbrio entre tecnologia e cuidado centrado no ser humano.

Conclusão: as inovações tecnológicas são ferramentas estratégicas na continuidade do cuidado e para mitigar riscos em desastres. Entretanto, ainda são necessários investimentos em infraestrutura, inclusão digital e políticas públicas sustentáveis.

Descritores: Atenção primária à saúde. Gestão em saúde. Preparação em desastres. Gestão de ciência, tecnologia e inovação em saúde. Tecnologia biomédica.

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RESUMEN

Objetivo: Analizar la literatura científica sobre las innovaciones tecnológicas implementadas en los servicios de Atención Primaria de Salud para la gestión de situaciones de desastres.

Método: revisión de alcance siguiendo el marco metodológico del Instituto Joanna Briggs. Se realizó en noviembre de 2024, en las bases LILACS, PubMed, Web of Science, CINAHL, EMBASE e IEEE Xplore. Se incluyeron artículos que relacionaban Atención Primaria de Salud, innovaciones tecnológicas y gestión de situaciones de desastres, y fueron organizados en Rayyan®.

Resultados: De 832 publicaciones, se seleccionaron 58 estudios (predominantemente de las Américas, entre 2021 y 2023). El análisis resaltó la telesalud, la inteligencia artificial y las herramientas inteligentes como innovaciones estratégicas en la Atención Primaria de Salud para la gestión de desastres. Estas tecnologías facilitaron la continuidad del cuidado tanto para necesidades específicas de desastres como para otros problemas de salud, mejorando significativamente el acceso y reduciendo riesgos. Sin embargo, persisten desafíos relacionados con la inclusión digital, las limitaciones de infraestructura y el equilibrio entre la tecnología y una atención centrada en la persona.

Conclusión: Las innovaciones tecnológicas son herramientas estratégicas para la continuidad del cuidado y para mitigar riesgos en desastres. Aún se requieren inversiones en infraestructura, inclusión digital y políticas públicas sostenibles.

Descriptores: Atención primaria de salud. Gestión en salud. Preparación ante desastres. Gestión de ciencia, tecnología e innovación en salud. Tecnología biomédica.

INTRODUCTION

Primary Health Care (PHC), the main entry point for users into health systems, plays a crucial role in the quality of the organization of services and coordination of care. Despite advances in PHC coverage[1], there are still significant gaps in health management, such as insufficient public funding, lack of equipment, variation in the profile of professionals, problems in coordinating care, different management models, and infrastructure and professional qualification issues, exacerbated by socio-economic inequalities. These challenges demand continuous innovation in public policies and health practices, with investments in professional training, Health Information and Communication Technologies (HICTs) and better working conditions[1].

In light of the challenges currently faced by global health systems, there is a growing need to strengthen PHC, particularly through research that contributes to exploring and validating innovation processes as one of the pathways to foster resilience and enhance care delivery. While not a standalone solution, such studies play a crucial role in shaping effective strategies to address the complex and evolving demands faced by healthcare worldwide. These studies should promote changes in the provision of services to the population, and may even lead to adjustments in health policies, with the ultimate aim of improving the quality of care provided[2].

HICTs, as strategic resources in PHC management worldwide, have been evolving since the 1960s and have accelerated after the 2019 pandemic, becoming guiding instruments for the processes of evaluation, incorporation, dissemination, management and quality of user care, driving the development of research in the area of artificial intelligence aimed at improving work processes[3–4].

The term "technological innovation in health" refers to the application of scientific and technological knowledge to solve problems that have an impact on changes in the diagnosis, treatment and prognosis of the individuals being cared for, reducing costs, helping professionals and improving the care process[5]. Health care is understood as a technology and defined as the art, the skill, the method, or the way of providing care. Hence, any advance or adaptation to meet the needs of the individual and their family is perceived and valued as innovation, since it provides improvement in living and health conditions[5–6].

These innovations are extremely necessary in the health sector and urgent in disaster situations. The global frequency of disasters resulting in public health emergencies—affecting millions—underscores this reality. Society's vulnerability to extreme weather events as well as the emergence of endemics and epidemics has increased significantly, especially as a result of disorderly urbanization and a lack of adequate planning. The limitations of public health policies exacerbate the events and their consequences[7], highlighting the need for more efficient and rapid action.

The introduction of technological innovations in PHC services has proved essential for the effective management of disaster situations. The perspective of the One Health model is particularly relevant in this context, as

it recognizes the interdependence between human, animal and environmental health in preventing and responding to public health emergencies, promoting a collaborative approach, highlighting the importance of technological innovation to facilitate communication, monitoring and decision-making[8].

Planning health actions in public health emergencies is essential to prevent, prepare for, respond to, mitigate and recover from impacts[9]. PHC plays a crucial role in all these stages, contributing significantly to risk reduction[10]. If it fulfills its role as a network organizer and is able to articulate multiprofessional and intersectoral work, PHC can act as an important strategic and management point for different types of disasters, as in the case of the Covid-19 pandemic.

The "Sendai Framework", adopted in March 2015 and effective until 2030, is the latest United Nations agreement for substantial disaster risk reduction, recommending a comprehensive and grounded set of propositions and targets for stakeholders[11]. In addition, the Sustainable Health Agenda for the Americas (2018-2030) reinforces PAHO member countries' commitment to targets that address emerging public health challenges at both regional and national levels, in line with the Sustainable Development Goals (SDGs). This includes the implementation of strategic plans and policies that guarantee equitable access to health services, even in disaster situations[12].

Thus, disaster management is a key challenge for global health systems, with PHC playing a critical frontline role. Integrating technologies into PHC enhances disaster preparedness and response. Reviewing scientific literature on this topic can reveal innovations and best practices to inform and strengthen health policies and strategies. Approaching the context of PHC, with a view to planning actions for multiprofessional teams that integrate risk management, especially at the community level, contributes to improving the health of populations from prevention to recovery through the series of circumstances involving public health emergencies[10]. A study identified gaps in this operation, including difficulties in protocolizing communication with the population, among team members, insufficient financial resources, a lack of knowledge regarding existing planning strategies and emergency protocols on the part of professionals, and the lack of time to develop strategies with the population, formulate plans, and conduct training. The evolution of risk perception can become the basis for the creation and development of successful interventions in PHC, facilitating communication with the population[13].

Latin American countries, in particular, frequently contend with a high burden of natural disasters and public health emergencies, such as epidemics, floods, and earthquakes, which disproportionately affect marginalized communities. Experiences in the region underscore the importance of community-based approaches, intersectoral collaboration, and the adaptation of technological solutions to local contexts[14–15]. However, challenges persist, as evidenced by studies highlighting gaps in PHC disaster operations—including difficulties in standardizing communication with the population and among team members, insufficient financial resources, limited professional training on emergency protocols, and constraints on time and personnel for developing and implementing community-level strategies and training.

A more precise understanding of how technological innovations are being adopted and adapted within PHC globally is essential for informing effective policies and strengthening disaster risk management. Therefore, this study aimed to analyze the scientific literature concerning technological innovations implemented in PHC services for disaster situation management.

METHOD

This is a scoping review following the methodological framework of the Joanna Briggs Institute and the recommendations of the PRISMA Extension for Scoping Reviews tool. The research protocol was approved by two reviewers, both researchers with experience in the subject and method, to guarantee the applicability of the question in the search for studies. The protocol was registered with the Open Science Framework (OSF): https://osf.io/7s3qa/?view_only=d6d058b00c7b40a78a38f885ec94b834.

The PICo strategy was used to present the research problem, which refers to: P (population): health professionals or PHC managers, I (intervention/interest): technological innovations implemented, Co (context): management of disaster situations. Therefore,

the research question was: What evidence is available on the technological innovations implemented in PHC to manage disaster situations?

Database searches were conducted in November 2024 from the LILACS (VHL), PubMed (NLM/NCBI), Web of Science, CINAHL (Ebsco), EMBASE (Elsevier) and IEEE Xplore databases, using the following terms (keywords and descriptors or Medical Subject Heading-MeSH) with the Boolean operator "AND" and "OR", as shown in Chart 1.

The criteria adopted for this review are detailed in Chart 2. Articles duplicated in the databases were only considered once.

Chart 1 - Presentation of databases, search strategies and total number of productions.

Database	Search strategy	Total search
LILACS	("Atenção Primária à Saúde") AND ("Aprendizado de Máquina" OR "redes neurais artificiais" OR "ciência de dados" OR "Processamento de Linguagem Natural" OR "Sistemas de Apoio à Decisão Clínica" OR "Inteligência Artificial" OR "Tecnologia Biomédica" OR "Tecnologia da Informação" OR "Invenções" OR "Biotecnologia" OR "Dispositivos Médicos" OR "Equipamentos e Provisões" OR "Tecnologia Médica" OR "Biomedicina" OR "Engenharia Biomédica" OR "Informática em Saúde" OR "Sistemas de Informação em Saúde" OR "Registros Eletrônicos de Saúde" OR "Telessaúde" OR "Telemedicina" OR "Saúde Digital" OR "eHealth" OR "Inovações" OR "Inovações Tecnológicas" OR "Inovações Médicas" OR "Patentes" OR "Novas Tecnologias" OR "Tecnologias Emergentes" OR "Inovação em Saúde" OR "Tecnologia" OR "Desenvolvimento Tecnológico") AND ("emergência em saúde pública" OR "desastre" OR "desastres" OR "emergências em saúde pública" OR "emergência") AND db:("LILACS") AND instance:"lilacsplus" AND db:("LILACS") AND instance:"lilacsplus"	52
PubMed	("primary health care"[All Fields] AND ("Supervised Machine Learning"[All Fields] OR "Deep Learning"[All Fields] OR "Unsupervised Machine Learning"[All Fields] OR "neural networks computer"[All Fields] OR "Multifactor Dimensionality Reduction"[All Fields] OR "data science"[All Fields] OR "Machine Learning"[All Fields] OR "Natural Language Processing"[All Fields] OR "decision support systems clinical"[All Fields] OR "Artificial Intelligence"[All Fields] OR "Biomedical Technology"[All Fields] OR "Information Technology"[All Fields] OR "Inventions"[All Fields] OR "Biotechnology"[All Fields] OR "Medical Devices"[All Fields] OR "Medical Technology"[All Fields] OR "Biomedicine"[All Fields] OR "Biomedical Engineering"[All Fields] OR "Health Informatics"[All Fields] OR "Health Information Systems"[All Fields] OR "Electronic Health Records"[All Fields] OR "Telehealth"[All Fields] OR "Digital Health"[All Fields] OR "eHealth"[All Fields] OR "Innovations"[All Fields] OR "Technological Innovations"[All Fields] OR "Medical Innovations"[All Fields] OR "Patents"[All Fields] OR "New Technologies"[All Fields] OR "Emerging Technologies"[All Fields]) AND ("public health emergency"[All Fields] OR "disaster"[All Fields] OR "disasters"[All Fields] OR "public health emergencies"[All Fields] OR "emergency"[All Fields])) AND (2020:2024[pdat])	287

Chart 1 - Cont.

Database	Search strategy	Total search
Web of Science	((ALL=("primary health care")) AND ALL=("Supervised Machine Learning" OR "Deep Learning" OR "Unsupervised Machine Learning" OR "neural networks, computer" OR "Multifactor Dimensionality Reduction" OR "data science" OR "Machine Learning" OR "Natural Language Processing" OR "Decision Support Systems, Clinical" OR "Artificial Intelligence" OR "Biomedical Technology" OR "Information Technology" OR "Inventions" OR "Biotechnology" OR "Medical Devices" OR "Medical Technology" OR "Biomedicine" OR "Biomedical Engineering" OR "Health Informatics" OR "Health Information Systems" OR "Electronic Health Records" OR "Telehealth" OR "Digital Health" OR "eHealth" OR "Innovations" OR "Technological Innovations" OR "Medical Innovations" OR "Patents" OR "New Technologies" OR "Emerging Technologies")) AND ALL=("public health emergency" OR "disaster" OR "disasters" OR "public health emergencies" OR "emergency")	82
Embase	'primary health care' AND ('supervised machine learning' OR 'deep learning' OR 'unsupervised machine learning' OR 'neural networks, computer' OR 'multifactor dimensionality reduction' OR 'data science' OR 'machine learning' OR 'natural language processing' OR 'decision support systems, clinical' OR 'artificial intelligence' OR 'biomedical technology' OR 'information technology' OR 'inventions' OR 'biotechnology' OR 'medical devices' OR 'medical technology' OR 'biomedicine' OR 'biomedical engineering' OR 'health informatics' OR 'health information systems' OR 'electronic health records' OR 'telehealth' OR 'digital health' OR 'ehealth' OR 'innovations' OR 'technological innovations' OR 'medical innovations' OR 'patents' OR 'new technologies' OR 'emerging technologies') AND ('public health emergency' OR 'disaster' OR 'disasters' OR 'public health emergencies' OR 'emergency') AND [article]/lim AND ([english]/lim OR [portuguese]/lim OR [spanish]/lim) AND [2020-2024]/py	208
CINAHL	MW "primary health care" AND MW ("Supervised Machine Learning" OR "Deep Learning" OR "Unsupervised Machine Learning" OR "neural networks, computer" OR "Multifactor Dimensionality Reduction" OR "data science" OR "Machine Learning" OR "Natural Language Processing" OR "Decision Support Systems, Clinical" OR "Artificial Intelligence" OR "Biomedical Technology" OR "Information Technology" OR "Inventions" OR "Biotechnology" OR "Medical Devices" OR "Medical Technology" OR "Biomedicine" OR "Biomedical Engineering" OR "Health Informatics" OR "Health Information Systems" OR "Electronic Health Records" OR "Telehealth" OR "Digital Health" OR "eHealth" OR "Innovations" OR "Technological Innovations" OR "Medical Innovations" OR "Patents" OR "New Technologies" OR "Emerging Technologies") AND MW ("public health emergency" OR "disaster" OR "disasters" OR "public health emergencies" OR "emergency") - Restringir por Language: - spanish Restringir por Language: - english	60

Chart 1 - Cont.

Database	Search strategy	Total search
IEEE Xplore	Showing 1-25 of 143 resultsfor ("Full Text & Metadata":"primary health care") AND ("Full Text & Metadata":"Supervised Machine Learning" OR "Full Text & Metadata":"Deep Learning" OR "Full Text & Metadata":"Unsupervised Machine Learning" OR "Full Text & Metadata":"neural networks, computer" OR "Full Text & Metadata":"Multifactor Dimensionality Reduction" OR "Full Text & Metadata":"data science" OR "Full Text & Metadata":"Machine Learning" OR "Full Text & Metadata":"Natural Language Processing" OR "Full Text & Metadata":"Decision Support Systems, Clinical" OR "Full Text & Metadata":"Artificial Intelligence" OR "Full Text & Metadata":"Biomedical Technology" OR "Full Text & Metadata":"Information Technology" OR "Full Text & Metadata":"Inventions" OR "Full Text & Metadata":"Biotechnology" OR "Full Text & Metadata":"Medical Devices" OR "Full Text & Metadata":"Medical Technology" OR "Full Text & Metadata":"Biomedicine" OR "Full Text & Metadata":"Biomedical Engineering" OR "Full Text & Metadata":"Health Informatics" OR "Full Text & Metadata":"Health Information Systems" OR "Full Text & Metadata":"Electronic Health Records" OR "Full Text & Metadata":"Telehealth" OR "Full Text & Metadata":"Digital Health" OR "Full Text & Metadata":"eHealth" OR "Full Text & Metadata":"Innovations" OR "Full Text & Metadata":"Technological Innovations" OR "Full Text & Metadata":"Medical Innovations" OR "Full Text & Metadata":"Patents" OR "Full Text & Metadata":"New Technologies" OR "Full Text & Metadata":"Emerging Technologies") AND ("Full Text & Metadata":"public health emergency" OR "Full Text & Metadata":"disaster" OR "Full Text & Metadata":"disasters" OR "Full Text & Metadata":"public health emergencies" OR "Full Text & Metadata":"emergency") Filters Applied: 2020 - 2025	143
	Total productions	832

Chart 2 - Criteria Adopted for Including and Excluding Studies

Inclusion Criteria	Exclusion Criteria
Original articles or experience reports	Reviews, editorials, letters to the editor, conference abstracts, dissertations, theses, other documents
Published since 2020. The year 2020 was established as the starting point for inclusion due to the profound global impact of the Covid-19 pandemic, which accelerated the adoption of health information and communication technologies (HICTs). This timeframe ensures the review reflects the most recent innovations and adaptations in disaster management and PHC care in response to health emergencies.	Focus outside the proposed topic (technological innovation in PHC for disaster management and health emergencies) or context irrelevant to the review
Available in Portuguese, English, or Spanish	No full-text access available

For the initial selection of titles and abstracts, the *Rayyan Qatar Computing Research Institute* (Rayyan® QCRI) tool was used, which facilitated the automation of the review, including identifying duplicates, incorporating a high level of usability and effectiveness of selection using the option of double blinding between reviewers. A PRISMA flowchart was constructed to represent the entire process of searching for and selecting articles and documents in the databases[16]. The PRISMA flowchart was drawn up with the help of the website[17]: https://estech.shinyapps.io/prisma_flowdiagram/.

To minimize possible selection bias, this selection was carried out in a double-independent manner by two researchers. When there was no consensus, a third (lead) researcher was consulted. The selected articles were then read in their entirety and analyzed based on the evaluation matrix which took into account the JBI recommendations: Bibliometric measurement data (Author; Year of publication; Journal of publication; and country where the research was conducted); Characterization of the primary studies (type of study); Answer to the research question (in descriptive form, with the studies subsequently grouped by category); and Level of evidence. The classification into seven levels of evidence was considered[18]: Level 1 (N1): Systematic review or meta-analysis of randomized controlled clinical trials; Level 2 (N2): Randomized controlled clinical trials; Level 3 (N3): Clinical trials without randomization; Level 4 (N4): Cohort and case-control; Level 5 (N5): Systemic review of descriptive and qualitative studies; Level 6 (N6): Descriptive or qualitative study; Level 7 (N7): Expert opinion.

The selected studies were organized in a summary table containing article reference; objective; study design; main results in response to the research question; level of evidence.

With regard to ethical and authorial aspects, a record was kept of all the stages of the review, and the ideas and definitions of the authors were respected, maintaining the authenticity of the articles researched, ensuring authorship and citation in the references in accordance with copyright regulations. The researchers declare that there is no conflict of interest that could influence the interpretation of the results.

The findings were organized, and data analysis was conducted using Content Analysis as proposed by Bardin[19], structured in three phases: pre-analysis, material exploration, and treatment of results, inference, and interpretation. In alignment with the review objectives, thematic categories were adopted. This approach enabled a systematic and coherent interpretation of the findings, ensuring fidelity to the original information and the scope of the study.

To ensure conceptual homogeneity regarding "technological innovation" and "digital solutions," a broad definition was adopted, considering technological innovation in health as the application of scientific and technological knowledge to address practical problems. Within this definition, digital solutions—such as telehealth, mathematical models, artificial intelligence, and information management systems—are considered contemporary manifestations of innovation. The search strategy employed a range of broad and specific descriptors, enabling the inclusion of various types of digital health interventions. During study selection, the principal criterion was whether the technology represented a novel approach aimed at improving care or management in PHC during disaster situations. This allowed for the diverse tools identified to be grouped thematically, ensuring analytical coherence throughout the review.

RESULTS

Of the 832 publications initially identified, two independent reviewers screened titles and abstracts according to predefined criteria, selecting 125 articles for full-text review. After detailed assessment for relevance and eligibility, 58 studies were included in the final sample. The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) was used to describe the search and selection of studies (Figure 1).

The identified studies were primarily from countries in the Americas (n=36), including the United States (n=26), Brazil (n=5), and Canada (n=5). In terms of study design, most employed quantitative approaches (n=43), with cohort (n=14) and cross-sectional (n=13) types being prevalent. The remainder consisted of mixed-method (n=3) and qualitative (n=12) approaches, which included descriptive research (n=6), experience reports (n=3), and case studies (n=3). Regarding the publication period, there was a predominance of studies

published in 2021 (n=19) and 2023 (n=18), underscoring the growing interest in this topic in recent years. The synthesis of the identified articles is detailed in Chart 3.

The analysis of the articles resulted in three thematic categories presented in Chart 4.

Figure 1 - Flowchart of the database search.

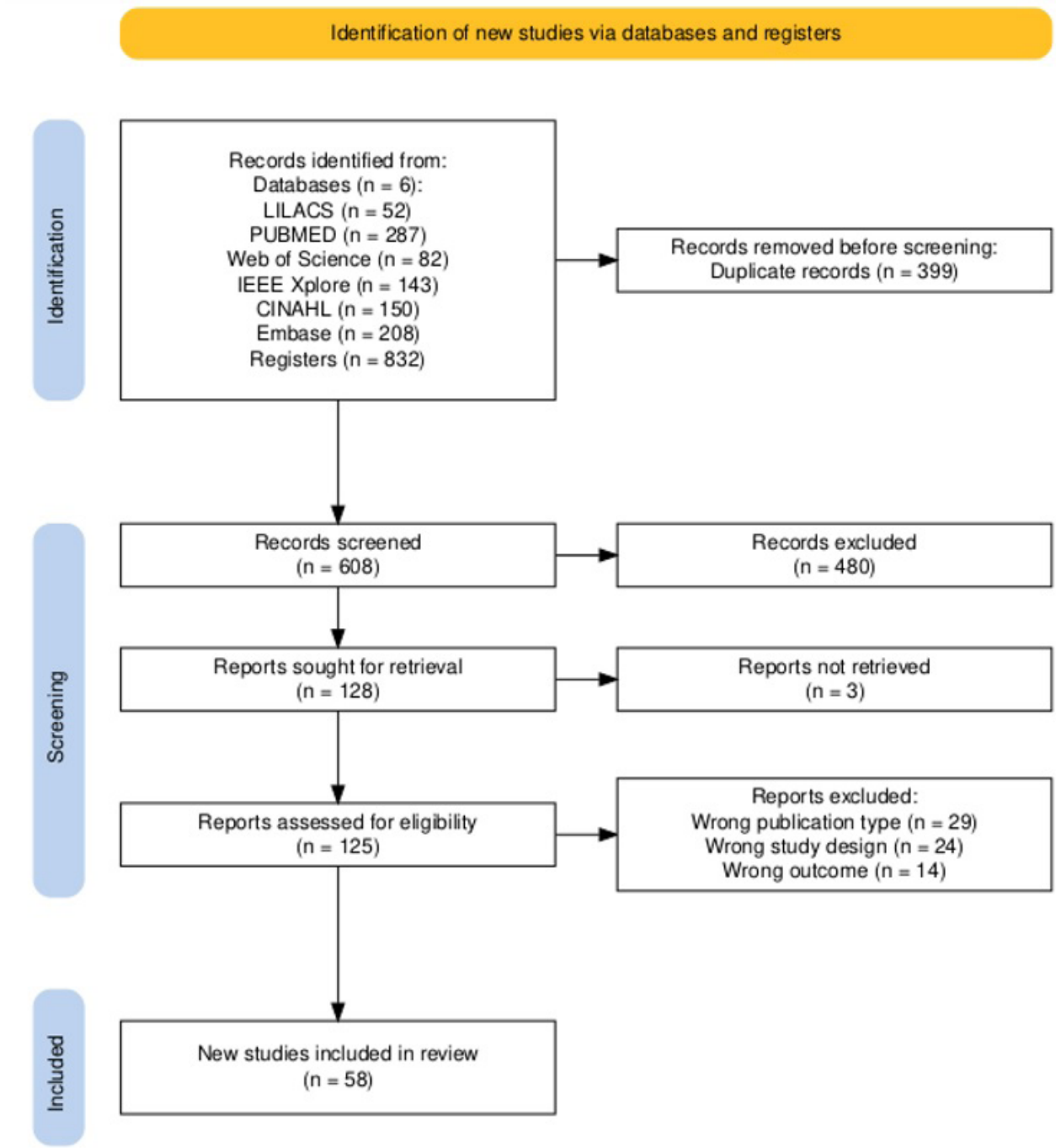

Chart 3 - Synthesis of articles identified in the review.

Article	Country / Year	Method/ Level of Evidence	Technology type	Objective	Specific Application & Mechanism
A1[20]	Brazil 2023	Quantitative ecological / 6	Teleconsultation	Develop a virtual teleconsultation platform for suspected Influenza Syndromes and Covid-19 infection cases	Virtual platform for teleconsultations aimed at triage, diagnostic support and follow-up of suspected cases of Flu Syndrome and COVID-19 to reduce in-person contact and manage case load.
A2[21]	Argentina 2023	Quantitative cross-sectional / 6	Teleconsultation	Compare interaction and communication between general practitioners and patients before and during the pandemic period	Teleconsultation platform to understand changes in general health care provision.
A3[22]	Uruguay 2023	Qualitative descriptive / 6	Teleconsultation	Describe the experience of mental health professionals working on the support line during the health emergency	Phone line for psychological support, operated by mental health professionals to provide remote support and counseling.
A4[23]	Mexico 2021	Quantitative cross-sectional/ 6	Telemedicine	Evaluate the conversion of an in-person diabetes primary care center to a telephone-based telemedicine service	Telephone-based telemedicine is analyzed concerning its efficacy in the management of diabetic patients (remote monitoring, medication adjustment, education).
A5[24]	USA 2024	Qualitative - Case report/ 6	Telehealth	Describe lessons learned from transitioning to Internet-based care during Covid-19	Health services based on the internet (telehealth), focusing on care continuity and adaptation during COVID-19 pandemic.
A6[25]	USA 2024	Quantitative cohort/ 4	Telehealth	Examine the association of telehealth with primary care use	Telehealth expansion, assessing the impact of internet speed on accessibility.

Chart 3 - Cont.

Article	Country / Year	Method/ Level of Evidence	Technology type	Objective	Specific Application & Mechanism
A7[26]	USA 2021	Quantitative cohort/ 4	Telehealth	Capture the impact of the pandemic on primary care service delivery	Use of telehealth platform modalities for service continuity.
A8[27]	USA 2022	Quantitative cohort/ 4	Artificial Intelligence	Evaluate an algorithm to identify patients vulnerable to severe Covid-19 complications	Evaluation of AI logarithm to identify patients that are highly vulnerable to severe complications due to COVID-19, using demographic and chronic condition data to allow for proactive interventions.
A9[28]	USA 2022	Quantitative cohort/ 4	Telehealth	Examine telehealth usage and changes in acute care rates	Evaluates if the telehealth platform affected the demand for acute care.
A10[29]	USA 2021	Quantitative cohort/ 4	Teleconsultation	Examine the effectiveness of a Covid-19 hotline	COVID-19 direct hotline to provide information, triage and guidance to patients.
A11[30]	Canada 2021	Quantitative cross-sectional/ 6	Telehealth	Document telehealth adoption by primary health service providers during the pandemic	Adoption of telehealth platform.
A12[31]	USA 2020	Qualitative descriptive/ 6	Telehealth	Understand physicians' experiences using telemedicine for elderly patients	Telemedicine platform for elderly patients, exploring the challenges and benefits of its use.
A13[32]	China 2020	Quantitative cross-sectional/ 6	Management	Investigate roles and training needs of general practitioners managing the coronavirus outbreak	Training of general practitioners in managing the coronavirus outbreak, focusing on preparing, answering and coordinating care.
A14[33]	USA 2021	Qualitative/ 6	Telehealth	Explore physicians' experiences providing telehealth for the elderly	Telehealth platform for elderly patients, focusing on strategies to ensure the continuity and quality of care.

Chart 3 - Cont.

Article	Country / Year	Method/ Level of Evidence	Technology type	Objective	Specific Application & Mechanism
A15[34]	Spain 2021	Quantitative descriptive/ 6	Teleconsultation	Analyze user profiles and usage patterns of the tool since the Covid-19 outbreak	Understanding the demand and acceptance of teleconsultation tools during the COVID-19 pandemic.
A16[35]	USA 2023	Quantitative cohort/ 4	Telehealth	Examine telehealth usage by homeless people in primary care	Use of telehealth by homeless people, analyzing the accessibility and challenges faced.
A17[36]	USA 2023	Quantitative cohort/ 4	Telehealth	Evaluate the association of advanced primary care with Covid-19 outcomes	Telehealth platform for managing cases and clinical outcomes.
A18[37]	Malaysia 2021	Qualitative/ 6	Smart tool	Evaluate the feasibility of the Covid-19 symptom monitoring system (COSMOS)	Feasibility of COVID-19 symptom monitoring system (CoSMoS) based on bot (ex. Telegram) for remote vigilance and case managment..
A19[38]	China 2021	Qualitative - Case report / 6	Telemedicine	Present response strategies of an integrated healthcare system during the pandemic	Use of an integrated health system, emphasizing the use of telemedicine and other innovations to ensure care continuity.
A20[39]	USA 2023	Quantitative cohort/ 4	Telemedicine	Examine changes in telemedicine use in rural vs. urban areas	Telemedicine platform. Aims at understanding disparities in access and implementation..
A21[40]	USA 2020	Quantitative retrospective/ 6	Telemedicine	Examine associations between telemedicine use in pediatric primary care and practice characteristics	Telemedicine platform . Evaluates impact on different clinical contexts.
A22[41]	USA 2024	Quantitative cross-sectional/ 6	Telemedicine	Analyze associations between daily telemedicine participation and electronic record time	Telemedicine platform and usage time of electronic record to evaluate efficiency and integration of digital tools.

Chart 3 - Cont.

Article	Country / Year	Method/ Level of Evidence	Technology type	Objective	Specific Application & Mechanism
A23[42]	USA 2023	Quantitative cohort/ 4	Telehealth	Evaluate pandemic impact on primary care delivery by the Clinical Resource Hub (CRH) Program	Clinical Resource Hub Program . (CRH) Explores how telehealth was integrated and its results.
A24[43]	USA 2021	Qualitative - Case study/ 6	Telemedicine	Explore telemedicine utility for comprehensive pulmonary embolism outpatient treatment with video visits	Use of telemedicine (video visits) for comprehensive pulmonary embolism outpatient treatment, assessing the safety and efficacy in a pandemic context.
A25[44]	Brazil 2020	Qualitative - Case report/ 6	Telehealth	Implement real-time telephone audiology for patients previously attended in outpatient clinics	Telephone audiology in real time for patients previously attended in person with the aim of continuing care during the pandemic.
A26[45]	USA 2023	Mixed/ 6	Telemedicine	Describe facilitators and barriers of telemedicine during Covid-19 for primary care clinicians	Facilitators and barriers of adopting the telemedicine platform by primary care clinicians during COVID-19.
A27[46]	Canada 2023	Quantitative cohort/ 4	Telemedicine	Compare health care usage after a virtual visit with own family doctor vs. external	Comparison between a virtual visit with own family doctor versus an external doctor, assessing continuation of care and patient preference.
A28[47]	Brazil 2022	Mixed/ 6	Teleconsultation	Describe development and expansion of synchronous teleconsultation for Covid-19 symptoms	Expansion of a synchronous teleconsultation service (in real time) for patients with COVID-19 symptoms.
A29[48]	United Kingdom 2024	Quantitative descriptive/ 6	Teleconsultation	Evaluate satisfaction with remote consultations during the pandemic	Evaluation of user satisfaction with primary care remote consultations during the pandemic.

Chart 3 - Cont.

Article	Country / Year	Method/ Level of Evidence	Technology type	Objective	Specific Application & Mechanism
A30[49]	Canada 2024	Quantitative descriptive/ 6	Telehealth	Explore occupational therapists' roles adaptation during the pandemic	Telehealth platform for the continuity and innovation of therapeutic services.
A31[50]	USA 2022	Quantitative descriptive/ 6	Management	Investigate system setup and information management with e-visits	System setup and information management with e-visits (virtual visits), analyzing how data management supports primary care.
A32[51]	Saudi Arabia 2023	Qualitative/ 6	Teleconsultation	Explore patient opinions on primary care during Covid-19	Teleconsultation platform during the pandemic.
A33[52]	Iran 2023	Quantitative cross-sectional/ 6	Telehealth	Determine continuity of care for chronic conditions during the pandemic	Telehealth platform for management of chronic conditions.
A34[53]	USA 2023	Quantitative cohort/ 4	Telehealth	Understand racial and psychosocial factors influencing integrated psychological service use	Telehealth platform for integrated psychological services in primary care during the pandemic.
A35[54]	Australia 2023	Quantitative cross-sectional/ 6	Telehealth	Investigate impact of pandemic response on primary care delivery in a remote community	Telehealth platform to access a remote aboriginal community.
A36[55]	USA 2023	Quantitative cohort/ 4	Telehealth	Understand substitution of in-person services with telehealth among US Medicare beneficiaries	Substituting in-person services with telehealth, analyzing use patterns and implications for general care delivery.
A37[56]	USA 2023	Qualitative - Case study/ 6	Teleconsultation	Present a case of SARS-CoV-2 infection and Herpes Zoster diagnosis in audio meetings	Audio meetings (teleconsultation), highlighting the usefulness of the modality by audio only.

Chart 3 - Cont.

Article	Country / Year	Method/ Level of Evidence	Technology type	Objective	Specific Application & Mechanism
A38[57]	USA 2022	Quantitative time series/ 6	Telehealth	Examine characteristics of virtual and video-based care in primary care	Characteristics of virtual and video-based care in primary care, analyzing tendencies and factors associated with the use of telehealth over time.
A39[58]	UAE 2022	Quantitative cross-sectional/ 6	Telemedicine	Study effect of pandemic on telemedicine use	Perception and acceptance of patients and health professionals of telemedicine use.
A40[59]	Australia, South Africa, Egypt, Nigeria 2022	Quantitative descriptive/ 6	Telehealth	Report learnings from Covid-19 primary health approaches	Exhibit of telehealth initiatives in different countries.
A41[60]	Canada 2020	Quantitative cross-sectional/ 6	Management	Explore scalability assessment among primary care innovators for expansion	Assessing scalability among primary care innovators for expansion, focusing on how new strategies are implemented and broadened.
A42[61]	China 2020	Quantitative descriptive/ 6	Management - Information system	Understand role of information management systems in public health	The role of information management systems in public health, assessing the efficacy and challenges in the collection and use of data for primary care.
A43[62]	Brazil 2021	Quantitative cross-sectional/ 6	Telemedicine	Present national telehealth service actions in Brazil	Telehealth platform.
A44[63]	Brazil 2021	Quantitative cross-sectional/ 6	Artificial Intelligence	Analyze spatial AI use in Covid-19 immunization resource allocation	Spatial Artificial intelligence for optimization of resource allocation during the immunization campaign against COVID-19, aiming efficiency and equity.

Chart 3 - Cont.

Article	Country / Year	Method/ Level of Evidence	Technology type	Objective	Specific Application & Mechanism
A45[64]	Italy 2021	Quantitative cohort/ 4	Artificial Intelligence	Develop deep learning-based decision tree for stratifying Covid-19 patients	Deep learning-based decision tree for stratifying COVID-19 patients, predicting the need for hospitalization and optimizing triage.
A46[65]	USA 2021	Quantitative retrospective/ 6	Telehealth	Develop pandemic preparedness protocols for opioid treatment programs	Pandemic preparedness protocols in opioid treatment programs, including the use of telehealth to ensure continuity of treatment.
A47[66]	USA 2021	Quantitative retrospective/ 6	Telehealth	Examine office resource use by primary care patients initially assessed via telehealth	Understanding the effectivity of remote triage.
A48[67]	Turkey 2021	Quantitative descriptive/ 6	Smart Tool	Provide a mathematical model for APS policy decision simulations	Mathematical model for simulation of APS policy decisions specifically for situations of COVID-19 outbreaks, optimizing intervention strategies.
A49[68]	Poland 2021	Quantitative cross-sectional/ 6	Telemedicine	Evaluate pandemic impact on patients' health habits and attitude towards vaccination	Role of telemedicine on communication and engagement regarding vaccinations.
A50[69]	Botswana, Ghana, Nigeria, South Africa,]Uganda, Zimbabwe 2021	Qualitative/ 6	Telemedicine	Synthesize lessons from the pandemic	Telemedicine was used to maintain health care and management.
A51[70]	Gauteng 2021	Qualitative descriptive/ 6	Telehealth	Describe health system response during the pandemic's first wave	Use of triage and tracking apps (telehealth) to monitor and manage cases.

Chart 3 - Cont.

Article	Country / Year	Method/ Level of Evidence	Technology type	Objective	Specific Application & Mechanism
A52[71]	USA 2022	Qualitative - Case study/ 6	Telemedicine	Describe innovative telepsychiatry use for "on-site" psychiatric screening	Innovative psychiatric use for on-site psychiatric screening in rural areas aiming to mitigate the scarcity of mental health professionals.
A53[72]	USA 2023	Quantitative cohort/ 4	Telehealth	Evaluate changes in visits by diabetes patients before and after telehealth implementation	Evaluating changes in visits of diabetes patients before and after telehealth implementation, analyzing the impact on the frequency and modality of consultations.
A54[73]	Canada 2023	Qualitative - Case study/ 6	Teleconsultation	Describe systems to mitigate Covid-19 exposure in primary care settings	Use of hotlines and virtual care to protect patients and teams.
A55[74]	USA 2023	Quantitative cross-sectional/ 6	Telemedicine	Examine office and telemedicine primary care use for insured patients	Comparison of modalities and patterns of use of in-person versus telemedicine care.
A56[75]	USA 2020	Mixed/ 6	Management	Understand necessary support for home care programs during natural disasters	Home care programs during natural disasters.
A57[76]	USA 2021	Quantitative quasi-experimental/ 6	Telehealth	Describe care utilization changes by homebound acute myocardial infarction patients during the pandemic	The use of telehealth tools in maintaining follow-up.
A58[77]	Australia 2022	Quantitative retrospective/ 6	Telehealth	Analyze implementation of digital health technologies for high-quality primary care continuity	Implementing digital health technologies to ensure the continuity of high quality primary care, evaluating its impact and challenges in daily practice.

Chart 4 – Thematic categories of studies analyzed in the scoping review.

Thematic categories	Topics	Articles
Technological innovations for care management in PHC during disaster situations	Use of Telehealth via virtual platforms, phone lines, messaging apps, audio and video, SMS	20,29,36,38,45,47,56,59,66, 73
	Use of intelligent tools and artificial intelligence	27,37,63–64,67, 70
	Management processes	32,38,59,62,69, 75
Technological innovations for managing other diseases in PHC during disasters	Use of Telehealth for general diseases	21,25–26,30,34,41–42,46,48,51,54–55,57–58,68,74, 77
	Use of Telehealth for chronic conditions	23,52, 72
	Use of Telehealth for elderly patients	31, 33
	Use of Telehealth for homeless populations	35
	Use of Telehealth for acute health events	28,43, 76
	Use of Telehealth for pediatrics	40
	Use of Telehealth for mental health	22,39,53, 71
	Use of Telehealth by specific professional groups	44, 49
	Management processes	24,50,60–61
Potentialities and challenges of technological innovations for disaster management in PHC		24,26,30,39,41,45,48–49,54,56, 59

DISCUSSION

Theme 1: Technological innovations for care management in PHC during disaster situations

The scoping review analysis highlighted 22 articles investigating technological innovations for care management in PHC during disaster situations, where the Covid-19 pandemic was the primary focus (n=21).

In this context, telehealth emerged as a critical innovation for managing suspected or confirmed Covid-19 cases. Studies described telehealth as utilizing virtual platforms[20,36,38,45,47], phone lines, and mobile messaging apps such as WhatsApp and SMS[29,45,59,66,73]. Studies[56,59,66] showcased the adaptability of these pre-existing tools for new purposes during the pandemic, leveraging broad access to mobile devices, which ensured the flexibility of telemedicine, particularly for patients unable to attend video consultations. Furthermore, telehealth helped limit patient exposure to others, resulting in reduced case rates, hospitalizations, and mortality[36, 66].

On the use of intelligent tools and artificial intelligence, innovative systems were developed, such as CoSMoS, a bot-based symptom monitoring system developed in in Malaysia that used the Telegram

messaging platform[37]; triage and tracking applications in South Africa[70]; and mathematical models in Turkey simulating outbreak scenarios[67]. In the United States, an algorithm identified patients that were more vulnerable to severe Covid-19 complications, utilizing demographic and chronic condition data[27]. In Brazil, spatial artificial intelligence optimized resources for the national Covid-19 vaccination campaign[63], while in Italy, a deep learning-based decision tree was created to enhance triage and predict hospitalization needs for Covid-19 patients[64].

Regarding management processes as a strategy to foster innovation in disaster situations in PHC, studies emphasize the organization of services and training of professionals to respond effectively to health emergencies. These studies highlight the importance of training health professionals[32,69] on case management, the implementation of preventive measures, the appropriate use of personal protective equipment, safe handling of diagnostic samples, and psychological support for patients. Moreover, they underline the importance of public education by PHC teams during consultations, with the use of social media, online platforms, phone calls, and educational materials to disseminate reliable information[32,70].

Other strategies identified as effective during the Covid-19 pandemic include: expanding the PHC workforce[38,62]; integrating resources for efficient regional use[38,62]; incorporating digital health into service delivery[38,59,62,69]; developing and implementing standardized operational procedures[70] and teleconsultation manuals[62]; mobilizing PHC for surveillance and case diagnosis, providing community care, and conducting vaccination campaigns[59,69–70]; retaining highly trained teams experienced in public health emergencies[62]. Community health agents were highlighted as indispensable resources in delivering supplies and offering continuous patient follow-up[69].

Additionally, one study on natural disasters[75] stressed the critical importance of distinct phases in emergency management: preparation, response, and recovery. The study emphasized support for home care programs to assist teams and patients during natural disasters, including phone visits and the swift resumption of care for patients.

In the field of Nursing, technological innovations broaden the scope of practice, enabling remote monitoring, health education, coordination of multiprofessional teams, and epidemiological surveillance activities. However, they require preparation to handle digital platforms, critical evaluation of the algorithms used, and advocacy for the inclusion of the profession's ethical principles in the governance of these technologies[25,39,45,49]. The recognition of nursing's leadership, especially of community health workers in PHC[69], highlights the need for articulation between technical-scientific training, professional recognition, and active participation in the definition and implementation of digital solutions, in order to ensure person-centered care and the reduction of inequalities.

Theme 2: Technological innovations and technologies for managing other health issues in PHC during disaster situations

This category included 33 articles that examined the expanded use of telehealth to manage various public health emergencies, such as the Covid-19 pandemic. It was evident that ICTs rapidly implemented during the pandemic were essential in maintaining healthcare quality, especially amid imposed physical restrictions[21,25,34,42,57,77].

Telehealth was widely used across different types of consultations, especially for chronic conditions such as hypertension[52] and diabetes mellitus[23,52,58,69,72], allowing these conditions to be managed during and after the public health emergencies [23].

Researchers also detailed the use of telehealth for elderly patients[31,33], stressing the necessity to improve the safety of care through investments in infrastructure and training policies. User privacy information and the benefits of telehealth were highlighted as essential[33].

Innovations in using internet technology for communication and remote consultations were explored, including telephone consultations[30], web platforms, and mobile health applications (mHealth)[24,74]. These technologies facilitate the collection and transmission of patient health data, like health history and biometric data, and integrate with connected devices like blood pressure cuffs and glucometers, providing PHC teams with crucial data for decision-making[24].

A study identified telehealth as an efficient resource for vulnerable populations. For example, a study found that homeless populations maintained robust use of remote health services even with limited access to information technologies[35]. It was also crucial for the continuity of acute care sensitive to PHC[28],among patients with acute myocardial infarction treated at home[76], or in cases of pulmonary embolism managed without hospitalization[43].

Programmatic PHC services, including pediatrics[40] and mental health[22,39,53,73], also benefited from telehealth, allowing continuity of care and mental health support even post-pandemic. This provides care opportunities for patients who otherwise might not attend a face-to-face consultation, such as higher-risk vulnerable populations, including elderly persons, pregnant women[53], and rural patients[39,71,73]. Telepsychiatric triage models were developed to mitigate unmet mental health needs, especially in areas with professional shortages[71].

Telehealth has proven to be an efficient resource for professional groups such as speech therapy services in PHC[44], enabling remote service and expanding access for patients in regions with a shortage of specialized professionals, ensuring the continuity of necessary care. A study[49] that explored telehealth use by occupational therapists, highlighted the development and implementation of new programs, as well as the expansion of existing initiatives in both disasters and day-to-day PHC delivery.

In management processes, innovations included the reordering of workflows to ensure preventive care and chronic disease management using both in-person and digital channels[24]. New analytical models were also proposed to optimize the primary care system and evaluate patient flow[50], along with management strategies focused on patient centrality and interprofessional collaboration[60]. The development of public health information management systems[61] and protocols, notably in opioid treatments integrated into PHC during disaster situations[65], were other observed innovation fronts.

Satisfaction evaluations with telehealth usage indicated that elderly individuals and those with lower educational levels might require additional support to benefit from these technologies, resulting in lower satisfaction levels[48,68]. There were also reports of satisfaction with the implementation of electronic prescriptions[68]. The effectiveness of telehealth was greater when there were pre-existing clinical relationships between professionals and patients within the PHC context[46,51]. One study showed that telehealth did not increase the number of follow-up consultations or surpass the number of in-person consultations, often being considered an effective alternative to in-person consultations, depending on specific medical needs[55].

Theme 3: Potentialities and challenges of technological innovations for disaster management in PHC

Technological innovations have shown various potentialities, such as accessibility provided by telehealth, benefiting particularly vulnerable patients and those in remote health areas[30]. This tool helped not only to reduce patient exposure during public health emergencies but also to protect professionals[30,59].

These transformations are directly aligned with international guidelines, such as the WHO Global Digital Health Strategy (2020–2025), which emphasizes the role of technology in strengthening resilient and inclusive health systems. Additionally, frameworks like the Sendai Framework for Disaster Risk Reduction and the United Nations Office for Disaster Risk Reduction) (UNDRR) agenda reinforce the importance of digital governance, intersectoral integration, and community engagement for effective emergency response, especially in contexts of vulnerability.

However, challenges have emerged, such as digital inclusion, as older patients or those with lower educational levels might need more support to access these innovations[48,54]. Technical limitations, like the lack of equipment and appropriate infrastructure for video conferencing (such as broadband internet access), were also noted[24,26], sometimes leading patients to prefer telehealth consultations with only audio[53,56].

Another highlighted scenario is the limited capacity of these technologies to completely replace human contact in consultations, which restricts detailed physical examinations and impacts the building of a therapeutic bond[30,45]. As a result, some digital tools, like remote monitoring systems and health apps, are

changing patient interactions with PHC professionals, leading to cost reductions[24].

On the other hand, telehealth can also affect the work dynamics of health teams, exacerbating multitasking and requiring a careful assessment of the workload[41,45]. It is also imperative to address language and communication barriers to better integrate diverse communities and patients with disabilities[24]. Therefore, public policies should encourage and enhance these innovations with continuous support for learning and structural adaptation of PHC teams and cultural demands, effectively addressing inequalities in access between rural and urban areas[25,39,45,49].

It is important for the nursing workforce to advocate for the integration of the profession's ethical standards into the design, management, and governance of technological solutions, aligning with global guidelines from agencies such as the World Health Organization (WHO) and the Pan American Health Organization (PAHO)[25,39,45,49].

CONCLUSION

Despite the expansion and positive impact of technological innovations in PHC during disaster situations, especially evident during the Covid-19 pandemic, important gaps remain. Digital access limitations, socioeconomic disparities, and communication barriers still restrict the reach and effectiveness of these solutions, particularly in vulnerable contexts.

For practice, it is recommended that health managers prioritize expanding digital infrastructure, promoting ongoing professional education, and adopting inclusive strategies to minimize digital exclusion. Strengthening management processes and adapting care flows to local realities are also essential for greater integration and rapid PHC response during emergencies.

In terms of public policy, there is an urgent need for regulatory frameworks that ensure the safe, ethical, and effective use of digital technologies, and for promoting intersectoral collaboration to address the social determinants underlying digital health inequities.

Future research should prioritize longitudinal and comparative studies on the impact of digital technologies in PHC, cost-effectiveness analyses, and investigations into user experiences and strategies to overcome contextual barriers.

In summary, digital innovations are strategic tools to strengthen the resilience and equity of PHC. Advancing public policies and research in this field is essential to ensure that the health system becomes more inclusive, prepared, and responsive to future emergencies.

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Data and materials availability

Access to the dataset may be obtained upon request from the corresponding author.

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