A comprehensive survey on federated learning for privacy preservation in digital healthcare applications

Review Published: 11 January 2026

Volume 68, article number 55 (2026) Cite this article

Knowledge and Information Systems

Aims and scope →

Submit manuscript →

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Abstract

Internet of Medical Things (IoMT) is a relatively new service that has the possible to revolutionize healthcare by connecting previously analog technologies digitally. Consequently, numerous healthcare applications based on IoMT are utilized in the course of daily life. Despite the abundance of machine learning (ML) techniques aimed at improving healthcare data management, none of them have been able to guarantee the data's complete privacy and security. The precise nature of the clinical data makes ML application difficult and yields unsatisfactory results. A new paradigm in ML called federated learning (FL) has arisen as a means to discover untapped potential in digital healthcare uses that protect patients' and clients' privacy without compromising their data. This survey comprehensively reviews over 105 peer-reviewed publications (2018–2025) sourced from IEEE, Elsevier, Springer, ACM, and MDPI digital libraries. It classifies existing FL approaches for digital healthcare based on architecture, communication

efficiency, privacy preservation, and application domain. Survey highlights key findings, comparative analyses with conventional FL-based systems, and lessons learned from prior studies. Finally, open challenges such as scalability, energy efficiency, model heterogeneity, and secure aggregation are deliberated, along with future research directions to enable trustworthy FL-based IoMT healthcare ecosystems.

Data availability

No datasets were generated or analyzed during the current study.

Abbreviations

IoMT: Internet of Medical Things

DL: Deep Learning

AI: Artificial Intelligence

ML: Machine Learning

IoT: Internet of Things

FL: Federated Learning

HFL: Horizontal Federated Learning

VFL: Vertical Federated Learning

FTL: Federated Transfer Learning

IIoT: Industrial Internet of Things

PRISMA: Preferred Reporting Items for Systematic Reviews and Meta-analyses

DRL: Deep Reinforcement Learning

CC: Cloud Computing

BC: Blockchain

IoHT: Internet of Health Things

DP: Differential Privacy

BiLSTM: Bidirectional Long-Short Term Memory

FL-PMI: Federated Learning-based Person Movement Identification

CNN: Convolutional Neural Networks

IDS: Intrusion Detection System

SPoF: Single Point of Failure

IoMT: Internet of Medical Things

IPFS: Inter-Planetary File System

$C^{2}T^{2}Net$ **:** Convolutional Capsule Twin Attention Tuna Optimal Network

MRI: Magnetic Resonance Imaging

AD: Alzheimer Detection

EXAI: Explainable AI

SC: Smart Contract

sSVM: Soft-margin L1-regularized Support Vector Machine

CFL: Clustered Federated Learning

DNN: Deep Neural Network

TL: Transfer Learning

ROI: Region of Interest

SMOTE: Synthetic Minority Oversampling Technique

DPFL-HIoT: Adaptive Differential security Federated Learning Healthcare Internet of Things

GBTM: Adaptive Gradient Boosted Trees method

PSO: Particle Swarm Optimization

FedSDM: Federated Learning Smart Decision Making

ECG: Electrocardiogram

EFL: Ensemble Federated Learning

FKD-Med: Federated Learning Knowledge Distillation Medical

IID: Independent and Identically Distributed

DPSGDFedAvg: Differentially Private Stochastic Gradient Descent utilized to Federated Averaging

EEIE: Extended ElGamal Image Encryption

ISCSO: Improved Sand Cat Swarm Optimization

FDCNN-AS: Federated Deep Convolutional Neural Network Alzheimer Detection Schemes

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Funding

No funding is provided for the preparation of the manuscript.

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Ethics declarations

Conflict of interest

The authors declare no competing interests.

Consent to participate

All the authors involved have agreed to participate in this submitted article.

Consent to publish

All the authors involved in this manuscript give full consent for the publication of this submitted article.

Ethical approval

This article does not contain any studies with human participants or animals performed by any of the authors.

Additional information

Publisher's Note

Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

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About this article

Cite this article

Kanauzia, R., Singh, M., Gulati, S. *et al.* A comprehensive survey on federated learning for privacy preservation in digital healthcare applications. *Knowl Inf Syst* **68**, 55 (2026). https://doi.org/10.1007/s10115-025-02673-2

Received
19 August 2025

Revised
29 November 2025

Accepted
13 December 2025

Published
11 January 2026

Version of record
11 January 2026

DOI
https://doi.org/10.1007/s10115-025-02673-2

Keywords

Federated learning Digital healthcare Privacy preservation Machine learning Internet of Medical Things Artificial intelligence