Cloud Computing in a Regional eHealth System: An AWS-Based Architecture

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Abstract

This report examines the use of cloud computing (specifically AWS - Amazon Web Services) in a regional eHealth system where patient records are processed in the cloud for remote access by providers and patients can locate physicians. We review cloud principles (NIST definition), service models (IaaS/PaaS/SaaS), and deployment types, and discuss virtualization, security, privacy, regulatory compliance (HIPAA/GDPR), SLAs, disaster recovery, interoperability (FHIR), cost-benefit, and scalability are critically analyzed. These concepts are applied to the case study, recommending an AWS architecture that leverages auto-scaling and multi-AZ redundancy. We evaluate risks (data breaches, downtime, vendor lock-in) and mitigation (encryption, IAM policies, backup/DR plans) and offer conclusions and recommendations.

Introduction

Cloud computing provides flexible, on-demand access to a shared pool of computing services such as servers, data storage, and software, delivered over the internet, with the ability to easily scale resources up or down. According to NIST, cloud computing *"is a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources"*. In healthcare, this enables storing and processing large volumes of patient data off-premises, giving clinicians anywhere-access to electronic health records (EHRs) and supporting telemedicine. For example, cloud-based EHRs allow authorized providers to retrieve patient records from any location, improving collaboration and adherence to data-sharing regulations. Large providers are transitioning away from private datacenters: Amazon, Microsoft and Google have invested in HIPAA-certified data centers to support cloud health applications.

In our case, a regional eHealth system uses AWS cloud infrastructure to process patient data and provide remote doctor access to health records, while patients can search for physicians and locations. This report examines the main cloud service models: Infrastructure as a Service (IaaS), Platform as a Service (PaaS), and Software as a Service (SaaS) along with different deployment types such as public, private, hybrid, and community clouds, as well as the virtualization technologies that form the foundation of IaaS. Security and privacy concerns are central: patient health data must be protected and comply with regulations (HIPAA in the US, GDPR in Europe). The cloud provider's Service Level Agreements (SLAs) and disaster recovery plans affect system availability. Interoperability standards (such as HL7 FHIR) are needed to integrate data across systems. We analyze cost-benefit trade-offs and scalability advantages of cloud versus on-premises.

This report draws on recent literature and applies these principles to an AWS-based solution. We identify relevant AWS services (e.g., VPC, EC2, RDS, S3, HealthLake, Lambda, API Gateway, Cognito, CloudTrail, KMS) and propose a multi-tier cloud architecture. We critically examine security risks, including data breaches and multitenancy issues, and mitigation strategies (encryption, IAM controls, monitoring). The goal is a distinction-level academic analysis guiding the design of a secure, compliant, and scalable cloud-based eHealth system on AWS.

Literature Review

Cloud Computing and Service Models

Cloud computing is widely adopted in healthcare, encompassing domains like EHR, telemedicine, imaging, and data analytics. The core models are *Infrastructure as a Service (IaaS)*, *Platform as a Service (PaaS)*, and *Software as a Service (SaaS)*. In IaaS, the provider delivers virtualized infrastructure: customers rent servers, storage and networking. For example, AWS EC2 allows healthcare IT to deploy custom EHR software without buying hardware. PaaS supplies a development environment; developers build and deploy applications on the provider's platform. (AWS Elastic Beanstalk or HealthLake's managed FHIR store can be seen as PaaS offerings for healthcare data.) SaaS offers complete applications over the cloud – e.g. a cloud-based EHR or patient portal that clinicians and patients use directly, with AWS hosting the app in the background. These models enable pay-per-use pricing: healthcare organizations avoid large capital expenditures, paying only for what they consume.

Virtualization is fundamental to IaaS: it allows multiple operating systems and applications to share physical hardware securely. In healthcare, virtualization enables resource pooling – e.g. many virtual machines can run on the same server, each isolated by a hypervisor. This drives up utilization and flexibility, but introduces security challenges around hypervisor vulnerabilities and inter-VM isolation (Zandesh 2024). A systematic review notes that "cloud computing users can access their programs and information using the Internet as a conduit" and that "shared resources, including servers, networks, storage tools, and application software, use cloud computing significantly". Thus virtualization supports multi-tenancy but must be carefully secured (e.g. rigorous patching and monitoring of hypervisors).

Deployment models define who controls and uses the cloud. A *private cloud* is operated exclusively for one organization, often on-premises or in a dedicated hosting environment; it offers greater control and may ease compliance but forfeits some scalability. A *public cloud* like AWS is owned by a provider and shared by multiple tenants; it maximizes elasticity but involves less direct control over infrastructure. Healthcare may also use *hybrid clouds* – combining a private cloud for sensitive data (e.g. a hospital's own datacenter) with a public cloud for less sensitive tasks – and *community clouds* where multiple organizations (e.g. a consortium of clinics) share infrastructure. The literature recommends hybrid models in healthcare when privacy or legacy integration is a concern.

Benefits and Limitations of Cloud in Healthcare

Cloud adoption in eHealth offers many potential benefits. Multiple sources highlight reduced costs as a primary advantage, since there is no need to purchase or maintain expensive hardware and software: organizations simply pay for cloud services as needed. Ahmadi and Aslani (2018) systematically reviewed cloud-based EHR implementations and found that cloud platforms improve cost-effectiveness, scalability, interoperability, and reduce errors through integrated data. Cloud services also yield "energy savings" by eliminating on-premise data centers and their cooling needs.

Importantly for patient care, cloud-hosted records mean data can be accessed *anytime and anywhere* by authorized providers. Continuous data availability supports telemedicine, remote monitoring, and better care coordination. Mehrtak et al. (2021) note that cloud systems improve *patient care due to continuous interaction*; doctors can analyze patient data regardless of location. Access to EHRs from mobile devices or the web enables remote diagnosis and specialist consultation. The eHealth Cloud Security Review also emphasizes that cloud-based medical records facilitate collaboration and overcome geographic barriers.

Cloud technology also enables robust disaster recovery. Leading providers replicate data across multiple availability zones or regions. Mehrtak et al. (2021) highlight that almost all cloud providers offer redundant systems, allowing rapid failover if a datacenter is lost. This protects against local hardware failures or disasters better than many on-premise systems can. In addition, the cloud's elasticity and auto-scaling mean that sudden spikes in demand (e.g. a health crisis) can be met by automatically provisioning more compute resources (Buyya et al., cited in Zandesh 2024).

However, there are limitations and challenges. Reliability depends on connectivity: if internet bandwidth is poor, user experience suffers. Indeed, Mehrtak et al. observe that availability and reliability issues can arise if the network connection is weak. Interoperability is another hurdle: healthcare requires standards (HL7, FHIR, DICOM, etc.) to exchange data across systems. Without consistent data formats, the promise of cloud-based information sharing is undermined.

Security and privacy are perhaps the most significant concerns. An open, shared environment can be vulnerable to data breaches and unauthorized access. Health data are highly sensitive; cloud storage multiplies the stakes. Regulations such as HIPAA (U.S.) and GDPR (EU) impose strict controls on health data. Compliance requires careful design: encryption at rest and in transit, rigorous access control, and auditability. Mehrtak et al. (2021) report that confidentiality and data integrity are frequent cloud security challenges. For instance, multi-tenancy and virtualization raise side-channel concerns if one tenant's VM could snoop another's memory (Bazm et al. 2019). Implementing strong isolation (secure hypervisors) and encryption are standard mitigations.

Regulatory factors impose additional constraints. Healthcare clouds must incorporate frameworks such as HIPAA (Health Insurance Portability and Accountability Act), HITECH, ISO 27001 series, and the EU's GDPR. These dictate requirements for consent, data localization, breach notification, and more. The literature emphasizes that cloud systems in health *"should comply with healthcare-specific regulations"* (Zandesh 2024). For instance, SAS has obtained HIPAA alignment for AWS services used in healthcare (e.g. as noted in Sachdeva et al. 2024). Solutions typically enforce role-based access control (RBAC), anonymization/pseudonymization of data, and data residency controls to meet GDPR.

Service Level Agreements (SLAs) are another consideration. Cloud providers typically guarantee high uptime (e.g. AWS offers 99.9% or better for core services). In healthcare, downtime can be life-threatening, so hospitals must plan backup access or failover procedures even with such SLAs. No specific SLA citation was found in the literature, but Mehrtak et al. note that cloud users have limited control over availability. Therefore, architects often use

multi-AZ deployment, routine backups (AWS Backup, RDS snapshots, etc.), and runbooks for failover to satisfy health system continuity requirements.

Cost-benefit analyses in the literature generally show cloud lowers upfront and maintenance costs. Mehrtak et al. and Ahmadi & Aslani agree that cloud adoption *"significantly decrease[s] in-house infrastructural and operational costs"*. Subscription models turn capital expenses into operational expenses, which can be scaled down if usage shrinks. Studies note that cloud avoids procurement delays and can provision capacity much faster (rapid deployment). However, total cost of ownership must consider ongoing cloud fees, data egress charges, and staffing for cloud management. Some sources (e.g.) emphasize that cloud reduces operating costs but add that keeping massive healthcare datasets available (for analysis) requires investment in security and infrastructure management.

Interoperability and Standards

Healthcare cloud systems must interoperate with other IT systems, both internal and external. HL7 FHIR (Fast Healthcare Interoperability Resources) has emerged as a leading standard for clinical data exchange. Nan and Xu (2023) note that the 2009 U.S. HITECH Act accelerated EHR adoption and led to national efforts (like the ONC's initiatives) to implement data standards. In response, HL7 formally introduced FHIR in 2014 as a web-friendly standard for healthcare resources. Recent reviews argue that FHIR can substantially improve interoperability in cloud health platforms because it is based on modern RESTful APIs, has explicit semantics, and widespread tooling (Gómez et al., 2022).

Using HealthLake or other FHIR servers allows different applications (EHRs, mobile apps, research databases) to exchange patient records in a consistent format. Interoperability also means aligning with local standards (like DICOM for imaging) and public APIs (e.g. SMART on FHIR for third-party apps).

Privacy and Security in Cloud Health Environments

Security and privacy in cloud health systems remain under active research. Zandesh (2024) develops a taxonomy of privacy and security factors, noting that "cloud computing in the health domain has markedly contributed to other technologies" but also that issues around privacy, transparency and legal boundaries are complex. Commonly recommended safeguards include end-to-end encryption using key management services (KMS), strict IAM policies, continuous monitoring (e.g. AWS CloudTrail, GuardDuty), and regular compliance audits. Mehrtak et al. (2021) identify encryption, authentication, and fine-grained access control as the most common countermeasures to confidentiality and integrity threats in health cloud platforms.

Data anonymization is also important when analytics are performed. Many health clouds implement de-identification or tokenization of PHI before using it in big data pipelines. For example, a healthcare research platform using AWS HealthLake applied HIPAA Safe Harbor rules to de-identify patient records before aggregation.

Cloud Service Level Agreements and Disaster Recovery

Large cloud providers offer SLAs for uptime (e.g. AWS guarantees 99.99% for many services). But in healthcare, even small outages can disrupt care. The literature suggests designing systems to tolerate downtime: using multi-region replication, automated backups, and failover strategies. Mehrtak et al. note that cloud providers "offer a redundant system and services" to enable disaster recovery. Accordingly, a robust AWS architecture should use multiple Availability Zones (AZs) within a region (and possibly multi-region replication), along with point-in-time recovery for databases (e.g. Amazon RDS snapshots and AWS Backup). Regular DR drills are recommended to ensure restoration procedures work under the RTO (recovery time objective) and RPO (recovery point objective) needed for healthcare.

Cost-Benefit and Scalability

Studies repeatedly find cloud's pay-as-you-go model reduces financial barriers for healthcare IT. Ahmadi and Aslani (2018) observed that the scalable nature of cloud computing allows healthcare organizations "to increase speed, efficiency and reduce overall expenses". Cloud systems easily scale resources up or down; if a hospital network suddenly needs more storage (e.g. for large imaging data) or compute (e.g. during analytics jobs), services like AWS Auto Scaling Groups or serverless computing (AWS Lambda) can automatically adjust capacity. One review notes that cloud's "infrastructure is scalable depending on processing and storage needs". Thus, the AWS solution can start small for a regional health system and grow with usage without massive upfront capital investment.

Summary of Review

In summary, cloud computing (especially on a provider like AWS) offers broad advantages for healthcare in terms of cost savings, accessibility, and scalability. However, realizing these benefits requires careful attention to the healthcare context: stringent security and privacy controls, compliance with HIPAA/GDPR, and use of interoperable data standards like FHIR. The deployment model (public/hybrid) should align with risk tolerance and legal requirements. The following analysis applies these principles to an AWS-based eHealth system architecture.

Discussion and Analysis

Architectural Design on AWS

For the regional eHealth case, we propose a modular cloud architecture on AWS. Patient records (EHR data) and application data reside in AWS managed storage, accessible via secure networks. A recommended design is a multi-tier architecture within an Amazon Virtual Private Cloud (VPC):

- **Network and VPC**: A dedicated AWS VPC spans multiple Availability Zones for high availability. Public and private subnets are defined: public subnets host load balancers or API gateways, while private subnets contain application servers and databases. Network Access Control Lists (NACLs) and Security Groups strictly control traffic. A VPN or

AWS Direct Connect can securely link the VPC to any on-premises hospital systems if needed (hybrid extension).

- **Application Layer**: For the remote access portal (web or mobile), we can deploy stateless application servers behind an Elastic Load Balancer (ELB). These servers run either on Amazon EC2 instances (with autoscaling groups for elastic scaling) or in containers via Amazon ECS/EKS. Alternatively, AWS Elastic Beanstalk could simplify deployment of web apps. Serverless options like AWS Lambda functions behind Amazon API Gateway can handle event-driven or lightweight functions (e.g. fetching data on request). For example, the People Heart Study used Lambda/API Gateway to build FHIR microservices on AWS. Using Lambda + API Gateway can simplify the "backend" by removing server management, though for heavy workloads EC2/EKS might be needed.

- **Data Layer**: Patient and clinical data should be stored in HIPAA-eligible services. For structured records, Amazon Relational Database Service (RDS, e.g. Aurora or RDS MySQL/Postgres) can serve as the transactional datastore. RDS supports encryption at rest and cross-AZ replication. For unstructured data (images, PDFs), Amazon S3 is ideal: S3 is highly durable, and S3 Glacier can archive older records for cost savings. Key AWS services like KMS can encrypt S3 buckets and RDS volumes with customer-managed keys. Optionally, AWS HealthLake can serve as a FHIR-native data store: it ingests clinical data (e.g. HL7 messages, JSON records) and auto-converts it to FHIR format for analytics. HealthLake is HIPAA-eligible and integrates with AWS analytics tools, which could support population health analytics or AI.

- **Caching and Search**: For quick lookup of physicians and locations by patients, AWS ElastiCache (Redis) can cache directory data. Alternatively, Amazon OpenSearch (Elasticsearch) could index physicians and support search queries (geospatial if needed) for fast retrieval.

- **Authentication and User Management**: AWS Cognito provides user identity and authentication for patients and clinicians. It supports integration with external identity providers (e.g. hospital SSO or social login) and MFA. Cognito can manage user pools and federated identities, ensuring only authorized users (patients or physicians) can access each API. It issues short-lived tokens used by API Gateway for secure calls.

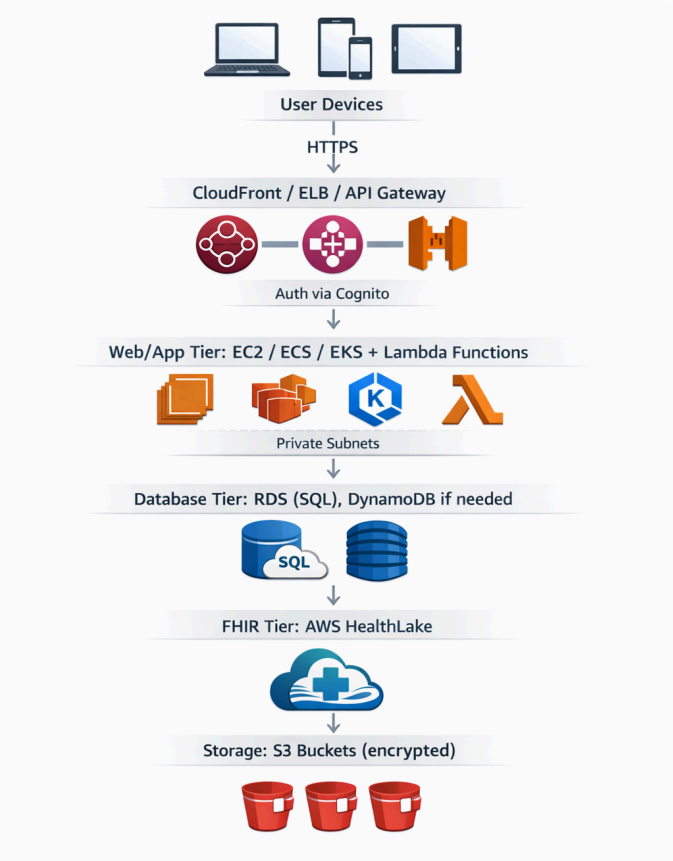
- **Interoperability/Integration**: All APIs and data exchanges use FHIR standards where applicable. AWS HealthLake ensures stored records are in FHIR R4 format, easing integration with third-party tools. API Gateway can enforce FHIR-based API paths and payload validation. The system can also integrate with existing hospital EHRs using AWS DataSync or third-party HL7 interfaces, converting legacy HL7v2 feeds into FHIR via Lambdas or third-party tools if needed.

- **Analytics and Machine Learning**: Cloud platforms like AWS can support advanced analytics and predictive modeling for healthcare applications (Ehwerhemuepha et al., 2020). For advanced functions, patient data (de-identified) in S3 or HealthLake could feed AWS analytics (Redshift, Athena) and ML (Amazon SageMaker, Comprehend

Medical). This supports predictive health analytics or NLP on clinical notes, though all such processing must respect privacy (data minimization, anonymization).

- **Monitoring and Logging**: AWS CloudWatch logs and metrics capture system performance; CloudTrail records all API calls for audit. AWS Config can evaluate resource compliance (e.g. ensuring encryption). AWS Security Hub and GuardDuty continuously monitor for anomalies. Centralized logging (e.g. on S3 with CloudWatch Logs) supports incident investigation.

A conceptual diagram:



Data flows securely through the VPC, with encryption in transit (TLS) and at rest. Security Groups ensure that only necessary ports/protocols are open. For example, the database subnets only accept inbound from the application subnets, and S3 access is through restricted VPC endpoints. IAM policies grant each service the minimum privileges (principle of least privilege): e.g. the app servers have a role to query RDS and S3; Lambda functions have roles scoped only to the health lake FHIR data.

AWS Service Relevance

Key AWS services in this context include:

- **Amazon EC2/EKS/ECS**: Compute resources to run custom applications (EHR frontend, APIs).

- **AWS Lambda & API Gateway**: Serverless functions for event-driven logic, building microservices (as in for FHIR).

- **Amazon RDS (Aurora)**: Managed relational DB for structured data (patient demographics, appointments).

- **Amazon S3 and Glacier**: Durable object storage for medical images, backups, logs. - **Amazon HealthLake**: Fully-managed HIPAA-eligible FHIR data store, ideal for storing normalized clinical data.

- **AWS Cognito**: User sign-up/sign-in with OAuth2, MFA for patients and doctors.

- **Amazon VPC**: Secure networking, isolation of resources. - **IAM & KMS**: Identity management and key management for encryption.

- **AWS CloudTrail, Config, CloudWatch, GuardDuty, SecurityHub**: Auditing, compliance, monitoring, and threat detection.

- **AWS Backup**: Centralized backup for RDS, EFS, DynamoDB, etc.

- **Amazon Route 53 & CloudFront**: DNS and CDN if needed for the patient portal.

Each of these services has specific features relevant to healthcare: for example, RDS and S3 are HIPAA-eligible when configured properly, and AWS publishes documentation on architecting for HIPAA compliance (Amazon Web Services, 2024). Cognito integrates with standardized login flows. HealthLake is built on HIPAA-eligible AWS infrastructure and automatically encrypts FHIR data. AWS architecture best practices (See AWS HIPAA Compliance whitepaper) emphasize VPC isolation, encryption, and logging for PHI workloads.

Security, Privacy, and Compliance

In this AWS architecture, security must be layered. The network layer uses VPC isolation and no public access to private resources. Data at rest should be encrypted: RDS offers encryption with KMS, S3 can enforce bucket encryption policies, and HealthLake encrypts its data using KMS keys. Data in transit should use TLS 1.2+ between clients and the API (API Gateway enforces this) and between AWS services. Multi-factor authentication (MFA) and strong password policies are enforced via Cognito for user accounts.

IAM roles and policies enforce least privilege: for example, application servers have an IAM role that allows reading from the EHR RDS and writing logs to CloudWatch only; they cannot delete records. Audit logs (CloudTrail) capture any administrative or data access actions. AWS Config rules can check for compliance (e.g. S3 buckets not public, RDS not publicly accessible).

HIPAA compliance requires signing a Business Associate Agreement (BAA) with AWS. AWS lists which services are covered; all services used above (EC2, S3, RDS, etc.) are covered (Amazon Web Services, 2024). Development teams should follow the AWS HIPAA

Implementation Guide. For GDPR compliance (if the region is EU), data residency matters: AWS Regions exist in many EU countries. The design could keep EU patient data in EU regions. AWS provides services (e.g. IAM Access Analyzer) to help with GDPR obligations. Data retention policies should allow deletion of patient data on request or when no longer needed (right to erasure).

A risk analysis identifies threats such as unauthorized access, data breaches, or insider errors. Mitigations include encryption, strong audit trails, intrusion detection (GuardDuty), and training staff on cloud best practices. Regular penetration testing and vulnerability scanning (AWS Inspector) should be done. Inherent in AWS's shared security model, AWS secures the infrastructure while the eHealth system owners must secure data and apps. For example, AWS ensures physical security and hypervisor security, but customers must ensure proper network security groups.

Disaster Recovery and Availability

The system must be highly available. AWS offers multi-AZ RDS with failover, and multi-AZ deployments for application instances. We recommend deploying replicas of critical components across two Availability Zones, so that the system continues if one AZ fails. Backups are crucial: enable automated RDS snapshots and back up S3 (even versioning or cross-region replication for extra durability). AWS Backup service can schedule and manage these. For failover, Route 53 can use health checks to direct traffic to a secondary region if necessary (Active-Passive multi-region strategy, albeit more complex and costly). Each disaster recovery plan should include RTO/RPO goals; AWS's rapid recovery tools (like cloning an AMI to spin up new EC2 in a different AZ) can meet tight RTOs.

We also must consider accidental deletions and data corruption. Versioning on S3 can protect against overwriting. In RDS, point-in-time restore allows rolling back to a consistent state. Regular backups should be tested by performing restores periodically.

Cost-Benefit and Scalability

AWS's pay-as-you-go model shifts costs from capital to operational. Initial costs are low since we provision only necessary resources. Ongoing costs (EC2 hours, Lambda invocations, S3 storage, data transfer) need careful monitoring; AWS Cost Explorer and budgeting tools can help avoid surprises. Compared to building an on-premises data center, AWS eliminates up-front hardware costs, and reduces IT maintenance overhead. According to Ahmadi and Aslani (2018), cloud adoption provides *"wide opportunities for managers, analysts and providers"* by lowering infrastructure barriers.

Scalability is achieved through AWS Auto Scaling. If the patient portal sees heavy usage, additional EC2 instances or containers will launch automatically. Serverless components (Lambda) scale immediately to handle incoming requests in parallel. This elasticity means performance remains stable even under variable load and has real-world benefits (Ehwerhemuepha et al., 2020).

HealthLake itself scales transparently with data volume: it handles up to petabytes of clinical data as claimed by AWS. This meets future growth needs. Moreover, AWS offers on-demand data warehousing (Redshift) and real-time data streaming (Kinesis) which can be adopted if large-scale analytics or real-time event processing (e.g. IoT health devices) are needed.

Interoperability

Our architecture uses FHIR standards to ensure interoperability. For example, if multiple hospitals participate in the regional system, each can contribute data via standardized FHIR APIs. The AWS HealthLake FHIR store ensures all patient records adhere to a common FHIR R4 schema, simplifying cross-system queries. API Gateway can enforce FHIR resource structures on inbound requests. The system could also publish FHIR interfaces for known services (e.g. FHIR endpoints for writing new encounter records). Adhering to FHIR greatly reduces custom data mapping between different EHR systems.

Integration with external systems (like national health exchanges) can be managed through FHIR APIs. If legacy systems are used, AWS Lambda functions can transform older HL7 v2 messages into FHIR before storage. This is supported by AWS official reference architectures and the People Heart Study example.

Risks, Benefits, and Mitigation

The analysis suggests key benefits of this AWS design are: ubiquitous access to patient data, reduced capital cost, auto-scaling to demand, and robust compliance alignment (given AWS's HIPAA-eligible services). It enables doctors to work remotely without VPNs (access through secure HTTPS portal with MFA) and lets patients easily locate and contact providers via a cloud search interface.

However, notable risks include:

- **Data Breach:** PHI leakage could occur if an attacker compromises keys or IAM credentials. *Mitigation:* Use hardware-backed keys (AWS CloudHSM or KMS), rotate credentials, apply strict IAM policies, and enable AWS CloudTrail to audit all data access. Conduct regular security assessments.

- **Downtime/Loss of Availability:** Cloud outages (rare but possible) could impact access. *Mitigation:* Deploy across multiple AZs and consider cross-region DR for critical data. Implement user-oriented fallback procedures (e.g. read-only cached data view) if writing is unavailable.

- **Insider Threat or Misconfiguration:** A staff error (e.g. misconfigured S3 bucket) could expose data. *Mitigation:* Use AWS Config rules, S3 block public access, and least-privilege IAM roles. Provide staff training on cloud security.

- **Vendor Lock-In:** Relying on AWS-specific services (like HealthLake) could make migration to another provider difficult. *Mitigation:* Architect with standards (FHIR APIs) so data can be exported. Use AWS proprietary tools judiciously.

- **Cost Overruns:** Unchecked resource usage can balloon costs. *Mitigation:* Tag resources, set budgets/alerts, and use AWS Trusted Advisor for cost optimization.

- **Compliance Violations:** Cloud misconfigurations could violate HIPAA/GDPR. *Mitigation:* Regular compliance reviews, leverage AWS Artifact for compliance reports, use encryption/pseudonymization to safeguard privacy.

Overall, the AWS environment provides strong technical means to enforce security and compliance, but governance (policies, audits) is equally vital. For example, the organization should execute a Business Associate Agreement with AWS and maintain documentation of HIPAA compliance measures. Regular penetration testing and third-party audits can validate controls.

Conclusion and Recommendations

Cloud computing on AWS can significantly enhance the regional eHealth system's capabilities, but it requires careful architecture and governance. We conclude that an AWS-based solution – employing VPC isolation, encrypted databases (RDS), object storage (S3), a FHIR data lake (HealthLake), and secure application tiers (EC2/EKS/Lambda with Cognito for auth) – can meet the system requirements for remote access, physician directory services, and patient privacy. This design aligns with cloud principles (resource pooling, elasticity) and supports multiple service models: IaaS (custom servers), PaaS (managed FHIR database), and SaaS (potential third-party apps).

Key recommendations include:

- **Security and Compliance:** Implement end-to-end encryption and strict IAM roles. Maintain audit logs (CloudTrail) and perform regular security assessments. Sign AWS HIPAA BAA. Incorporate GDPR-by-design (data minimization, user consent flows).
- **Disaster Recovery:** Use multi-AZ deployment and regular automated backups. Define RTO/RPO objectives and test recovery drills.
- **Interoperability:** Adopt HL7 FHIR standards (AWS HealthLake) for patient data to enable seamless exchange with other providers and EHR systems.
- **Scalability and Cost Management:** Leverage AWS Auto Scaling and serverless features to handle variable load cost-effectively. Monitor costs actively.
- **Governance:** Establish cloud governance policies. Conduct risk assessments on an ongoing basis. Provide staff training on cloud best practices.

By critically analyzing cloud computing models and AWS services, this report demonstrates that with proper design, the eHealth system can achieve improved accessibility, efficiency, and resilience. Future work should explore emerging AWS healthcare services (e.g., Amazon Comprehend Medical) for advanced analytics, and continually adapt the architecture to evolving compliance frameworks (such as the EU's upcoming Health Data Space regulations).

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