Smart Contracts in Shariah-Compliant Human Milk Sharing

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Abstract

This article explores the integration of smart contracts and blockchain technology in supporting Shariah-compliant human milk sharing. Donor milk sharing in Muslim communities presents unique challenges due to the Islamic concept of milk kinship, which establishes familial bonds through breastfeeding and influences marriage eligibility. Traditional recordkeeping practices related to human milk sharing (HMS) are either rarely practiced or lack systematic implementation, increasing the risk of unintentional violations of milk kinship rules and undermining trust in donor milk programs. This study aims to examine how blockchain-enabled smart contracts can address these gaps in a Shariah-compliant manner. Through a conceptual analysis drawing from Islamic jurisprudence and existing blockchain literature, this study discusses the mechanisms by which smart contracts can automate consent, verify donor and recipient identities and preserve kinship records. The discussion reveals that smart contracts offer a promising framework that aligns with Islamic principles of transparency, trust and privacy in managing milk kinship. Ultimately, this research highlights a meaningful intersection of faith, ethics and technology, offering a foundation for Shariah-compliant and ethically sound healthcare practices.

Keywords: *Smart contract, blockchain, human milk sharing, shariah-compliant, milk kinship*

1. Introduction

The integration of blockchain technology and Islamic principles is opening new opportunities for innovation in ethical service delivery. One of the emerging areas where this synergy is gaining momentum is human milk sharing, particularly within Muslim communities. This practice, while medically beneficial, raises unique religious and ethical concerns due to the concept of milk kinship in Islam, which establishes non-biological familial bonds through breastfeeding. These relationships carry significant implications, especially in regulating marital eligibility, necessitating careful adherence to Shariah guidelines. As modern healthcare systems evolve, there is an urgent need for technological solutions that can accommodate both medical imperatives and Islamic ethical frameworks.

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To address these needs, researchers and practitioners have started to explore Shariah-compliant milk sharing platforms that leverage the decentralized nature of blockchain technology. These platforms aim to securely document milk donation events and preserve accurate lineage records, thereby preventing unintended breaches of kinship-related prohibitions [1]. Beyond lineage tracking, blockchain offers additional advantages such as data immutability, traceability, and privacy protection, key features for managing sensitive healthcare records in accordance with both medical ethics and Islamic values [2]. Through these capabilities, blockchain functions as a trustworthy and transparent infrastructure, bridging the gap between established religious guidelines and contemporary health practices.

Importantly, the application of blockchain in Islamic contexts is not limited to healthcare. In Islamic social finance, blockchain particularly through the use of smart contracts, has been applied to enhance governance in institutions like waqf (charitable endowments) [3]. Smart contracts, which are digital agreements programmed to self-execute when predefined conditions are met, ensure transparency, accountability, and tamper-proof record-keeping. Their success in managing financial and charitable assets ethically and efficiently demonstrates a compelling precedent for their deployment in Shariah-compliant human milk sharing. Just as they regulate the distribution of charitable funds, smart contracts can also automate consent management, verify donor and recipient identities, and securely document milk kinship ties, minimizing the risk of human error and reinforcing religious compliance.

As such, smart contracts are emerging as critical tools not only in Islamic finance but also in bioethical governance. In the evolving landscape of Islamic FinTech, smart contracts are already being employed to ensure Shariah-compliant financial services [4]. Their extension into the domain of healthcare ethics particularly in regulating human milk sharing, represents a natural progression of this innovation. These early-stage developments illustrate the transformative potential of integrating blockchain and Islamic jurisprudence to deliver trustworthy, transparent, and ethically aligned solutions across sectors. This paper explores how smart contracts can be harnessed to support Shariah-compliant human milk sharing, addressing the complex intersection of faith, ethics, and technology in Muslim healthcare systems.

2. The Islamic Context: Human Milk and Fiqh

In Islamic jurisprudence, the concept of *radha'ah* (milk kinship) holds considerable religious and legal significance. It refers to the familial bond established when a child is breastfed by a woman other than their biological mother, rendering that child her milk child and creating milk sibling relationships with any others she nurses. This kinship prohibits future marriage between individuals breastfed under qualifying conditions (number of feedings and the child's age), even if biologically unrelated [5]. The prohibition is explicitly rooted in the Qur'an and elaborated extensively in hadith and classical Islamic legal texts [6-12].

These principles pose significant ethical and logistical challenges for the implementation of donor human milk bank in Muslim communities. Since receiving human milk from another woman establishes a form of kinship, it complicates anonymous milk donation and creates complex family ties that must be carefully

tracked [13]. Scholarly opinion is divided; some Islamic scholars permit milk banks if donor identities are documented and disclosed, while others oppose anonymous donation due to the risk of unknowingly forming prohibited kinship ties [14][15]. Consequently, many Muslim families exhibit reluctance toward using donor human milk unless they can verify the identity of the donor and ensure proper recordkeeping [5][51][52], which has slowed the development of human milk banks in Muslim-majority countries [5][16].

To address these concerns, scholars and technologists have proposed innovative, Shariah-compliant solutions. For instance, a digital platform for milk sharing that manages transactions, tracks lineage, and secures consent from both parties has been introduced [1] while other proposed a Conditional Identified Milk Banking System, which maintains transparency through a voluntary registry of both donors and recipients [16]. In Southeast Asia, where several nations have sizable Muslim populations, stakeholder perception studies have further examined how religious decrees (fatwas), healthcare policies, and community attitudes intersect in shaping the acceptability of milk sharing programs [17].

Historically, milk kinship records were maintained manually or through centralized religious institutions. This approach was prone to human error, data loss, and limited accessibility [1][18]. Recent advancements in digital technology offer promising alternatives. Blockchain, combined with smart contract systems, enables secure, transparent, and tamper-proof recordkeeping, automating identity verification and consent tracking while ensuring full compliance with Islamic legal requirements [3][19][20].

3. Smart Contracts: Enhancing Trust and Shariah Compliance in Milk Sharing

Smart contracts are self-executing digital agreements with the terms of the contract directly embedded in computer code. These contracts autonomously carry out specified actions once predetermined conditions are fulfilled, without the need for intermediaries [21][22]. In the context of human milk sharing, smart contracts offer a transformative solution to address issues of trust, traceability, consent, and compliance with Islamic law, particularly regarding the establishment of milk kinship.

This section outlines how smart contract technology can revolutionize the management of donor milk systems in Muslim communities:

a) Identity Verification and Consent Management
Before any milk sharing takes place, smart contracts can facilitate strict identity verification protocols for both the donor and the recipient family. These digital agreements can securely store consent declarations from all involved parties, ensuring that participants are fully informed of the religious implications of milk kinship. Such digital consent mechanisms support ethical transparency and adherence to Shariah principles by preventing unauthorized sharing or use of human milk [13][23]. Furthermore, smart contracts can be configured to reject transactions if proper identity documentation or consent is not provided, thereby upholding the integrity of

the milk donation process. This enhances legal and religious accountability, which is essential in culturally sensitive domains such as Islamic bioethics.

b) Immutable Recording of Milk Kinship
According to Islamic jurisprudence, a milk kinship bond is established when a child is breastfed five times or more by a non-biological mother during infancy. Smart contracts can be programmed to record this bond once the qualifying conditions are met, using permissioned blockchain technology to ensure data immutability and confidentiality [24][25]. Once the criteria are fulfilled, the smart contract automatically logs the milk kinship on the blockchain, generating a permanent, tamper-proof, and time-stamped record. This information can then be accessed by authorized stakeholders such as family members, Shariah authorities, healthcare professionals, or marriage registrars to verify kinship ties and prevent marriages that are religiously prohibited under Islamic law. The transparency and durability of these records strengthen both trust and legal certainty in milk sharing practices.

c) Privacy and Confidentiality Preservation
Privacy and modesty are central values in Islam. Therefore, any technological intervention must prioritize the protection of personal information. Blockchain's cryptographic framework offers strong data protection through mechanisms such as selective data disclosure and access controls [26][27]. These features allow for identity verification and kinship tracking without revealing sensitive personal information to the public. Through smart contracts, access to milk kinship records can be restricted to individuals or institutions with legitimate religious or legal authority. This ensures that data is only shared on a need-to-know basis, thereby aligning with Islamic norms on modesty and confidentiality [28][29].

This technology-driven approach not only promotes transparency and compliance with Islamic teachings but also opens the door to scalable, ethical, and culturally sensitive milk sharing systems. As interest in Islamic bioethics continues to grow alongside advancements in digital health technologies, the integration of smart contracts presents a promising pathway for reconciling tradition with innovation.

4. Proposed Conceptual Framework

To illustrate how Islamic principles and technological implementation are integrated, Figure 1 presents a conceptual framework mapping each Shariah requirement to its corresponding smart contract mechanism and the expected compliance outcome. The framework operates across two interconnected layers: a Fiqh Layer grounded in Islamic jurisprudence and a Technology Layer implemented through blockchain-enabled smart contracts.

Islamic Principles (Fiqh Layer)	Smart Contract Mechanism	Outcome / Shariah Compliance

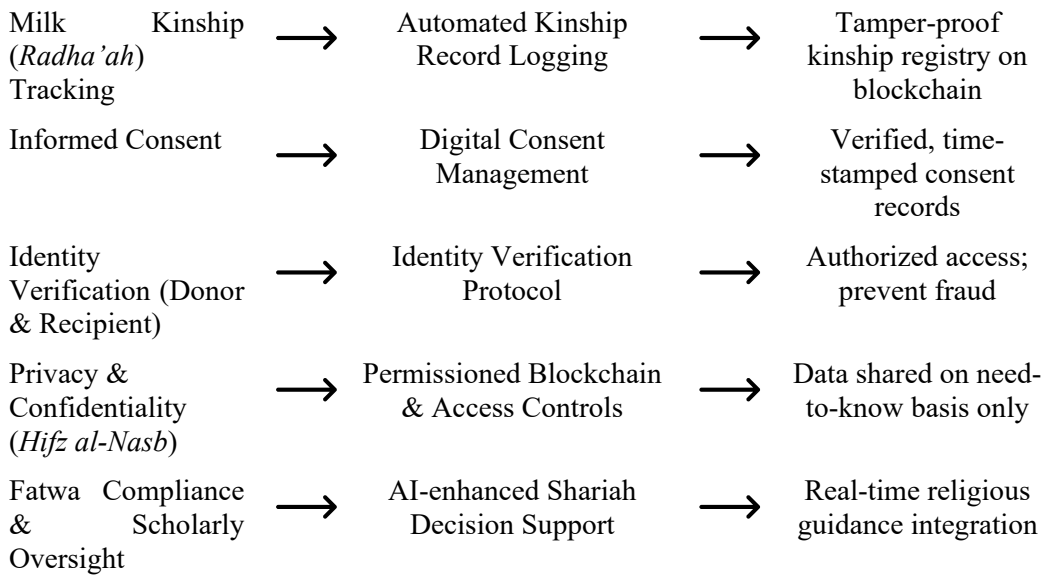

Figure 1. Conceptual Framework: Integration of Islamic Principles and Smart Contract Technology for Shariah-Compliant Human Milk Sharing

As illustrated in Figure 1, each Islamic principle is operationalized through a specific smart contract mechanism. Milk kinship tracking is addressed through automated kinship record logging on an immutable blockchain. Consent requirements derived from Islamic contract principles are fulfilled through digital consent management with time-stamped verification. Identity obligations are met through cryptographic access protocols, while privacy requirements aligned with the Islamic objective of protecting lineage (*hifz al-nasb*) are addressed through permissioned blockchain architecture. Finally, the integration of AI-enhanced decision support provides real-time fatwa guidance to complement scholarly oversight.

This dual-layer approach ensures that the technological system is not merely a functional tool, but an ethically governed infrastructure rooted in Islamic values.

5. Automating Ethical Oversight in Human Milk Sharing

The integration of smart contract technology into human milk sharing platforms offers a powerful mechanism for automating ethical and religious oversight, particularly within Islamic contexts. These platforms can be programmed with embedded Shariah-compliant protocols that govern milk transactions, ensuring that religious, medical, and legal criteria are consistently upheld [30-32].

Smart contracts can execute a series of automated checks prior to validating any milk sharing transaction. These include:

a) Verification of the Donor's Medical Background and Informed Consent: Donors must meet established health criteria and provide clear digital consent. This ensures that the milk is safe for infant consumption and that the donor fully understands the ethical and religious implications of the act.

b) Confirmation of the Recipient Child's Age: Islamic jurisprudence requires that milk kinship is only established if breastfeeding occurs within the first two years of a child's life. Smart contracts can automatically verify the child's age to determine whether the milk kinship rules apply.
c) Cross-Referencing with Existing Kinship Records: To avoid conflicts such as unintentional marriages between milk siblings, the system can automatically compare new entries against an existing blockchain-based registry of milk kinship. This helps identify and prevent overlapping or conflicting familial relationships.

By automating these ethical safeguards, smart contracts eliminate the need for manual vetting by religious or healthcare authorities at each stage of the process. This not only reduces the risk of human error and administrative delays but also ensures consistent application of Shariah principles across all transactions. Moreover, the use of tamper-proof, decentralized records provides a transparent and auditable system of oversight, thereby enhancing trust among stakeholders.

6. Applications Beyond Milk Sharing

While the primary focus of smart contracts and blockchain technology in this context has been to facilitate Shariah-compliant human milk sharing, their potential applications extend well beyond individual transactions. Two notable areas of expansion include the establishment of Islamic-compliant milk banking systems and the integration of artificial intelligence (AI) to support fatwa (Islamic legal opinion) interpretation and decision-making.

a) Milk Banking Networks
Human milk banks are well-established in many non-Muslim countries and play a critical role in providing nutrition for premature and vulnerable infants [53][54]. However, in many Muslim-majority contexts, milk banking has faced religious and ethical resistance due to concerns regarding the violation of Islamic kinship laws [16][33]. To address these challenges, some scholars have proposed Shariah-compliant frameworks that could legitimize milk banking under specific conditions. For instance, by using milk from a single known donor or by pooling milk from at least three different donors to anonymize kinship [34].

By integrating blockchain-enabled smart contracts into Islamic milk banks, it becomes possible to track the milk donation chain, from donor to recipient, ensuring transparency and traceability. It also can accurately record donor and recipient information, maintaining identity registries in a secure, tamper-proof system. Ultimately, it establishes milk sibling registries, which can be shared across institutions or geographic regions to prevent future kinship-related conflicts. Such innovations would enhance the credibility and religious acceptability of milk banks in Muslim communities, making them more feasible during humanitarian crises, in underserved regions, or in cases of maternal health complications. In turn, this could help address ongoing issues of infant malnutrition and mortality in a Shariah-compliant manner.

b) AI-Enhanced Smart Contracts for Fatwa Integration
In the near future, AI technologies could be paired with smart contract systems to automate and personalize religious guidance related to milk kinship and Islamic bioethics. These systems could offer real-time Shariah decision-making in complex or borderline cases by referencing authoritative fatwas and scholarly opinions.

A promising development in this field is the use of artificial intelligence for automating aspects of fatwa generation, particularly in Islamic finance and legal advisory contexts. A study has developed foundational datasets and baseline models for classifying Islamic legal questions and matching them with appropriate rulings and further advanced the development of AI-driven fatwa systems, highlighting the potential of machine learning to enhance the consistency, speed, and accessibility of religious legal opinions [35][36]. These studies demonstrate the feasibility of integrating AI into religious decision-support systems, including those for bioethical use cases like milk sharing.

In the context of Islamic milk banking and kinship determination, such AI systems could help interpret fatwas in real time based on scenario-specific factors, assist healthcare professionals in complying with Islamic legal frameworks and provide decision support where scholars are unavailable or rulings are unclear.

However, this technological shift raises critical ethical and theological concerns. While AI may serve as a valuable tool to support fatwa issuance, its use must be carefully regulated to prevent oversimplification or misinterpretation of nuanced religious rulings [37]. Human oversight, contextual judgment, and theological responsibility cannot be fully replicated by algorithms. Therefore, AI should be deployed as a complementary support mechanism, not as a substitute for qualified Islamic scholars (muftis).

Complementing these scholarly discussions is a real-world application introduced by Datuk Seri Dr. Zulkifli Mohamad Al-Bakri, former Mufti of the Federal Territories. In 2025, he launched AI-powered Syariah officers (Dr. Munir and Dr. Munirah) under the Maktabah Al-Bakri platform, designed to answer thousands of questions related to Islamic law and contemporary issues [38][39]. These AI tools are powered by ChatGPT Plus and built in collaboration with Hedra Studio. According to Dr. Zulkifli, the initiative aims to enhance access to Islamic knowledge among digital-native users and promote responsible use of AI in religious contexts [40].

Nevertheless, religious authorities and scholars have cautioned that while AI can increase efficiency and access, it must not compromise the sanctity of religious discourse. Analysts have called for strict governance frameworks to ensure doctrinal integrity and prevent the misuse of AI in matters of faith and law [41].

7. Smart Contracts as Custodians of Ethical Milk Sharing

Smart contracts have the potential to function as digital custodians of Shariah ethics in the context of infant feeding and milk sharing [42][43]. One of the most pressing concerns in Muslim communities regarding donor milk is the ambiguity surrounding milk kinship lineage [5][44]. Smart contracts directly address this by accurately recording and verifying feeding events, thereby eliminating confusion about milk sibling relationships. Such systems ensure that milk kinship is clearly established, traceable, and securely documented in line with Islamic jurisprudence.

In addition, these contracts offer end-to-end auditability and transparency [45-47]. Smart contracts can automate processes, ensure protocol compliance, and facilitate secure information exchange among stakeholders [47][48]. The immutability and transparency of blockchain technology improve trust between all parties involved, including donors, recipients, medical professionals, and regulators [46]. Every transaction, from donor identity verification to consent and delivery can be logged and reviewed on a permissioned blockchain. This ensures that all exchanges are not only medically safe but also fully compliant with religious requirements.

Most importantly, smart contracts can empower Muslim families to make informed and confident decisions. With embedded religious safeguards and automated Shariah checks [22], parents are reassured that their actions uphold Islamic values without compromising on infant nutrition or safety. These technologies align with Islamic principles by promoting trust, reducing uncertainty (gharar), and enabling decentralized verification [43]. Smart contracts can automate Islamic contractual processes, making them easier to verify, immutable, and secure [49][50].

In this light, the integration of Shariah-compliant smart contracts represents more than a technological advancement. It signifies the creation of a moral infrastructure within modern healthcare. By uniting Islamic ethical principles with digital innovation, such systems offer a sustainable and trustworthy model for managing human milk sharing in Muslim societies.

8. Conclusion

The concept of milk kinship remains central to Islamic bioethics, particularly in guiding norms around infant feeding, familial bonds, and marriage prohibitions. In Muslim societies, navigating modern healthcare challenges such as access to donor milk, requires approaches that remain firmly rooted in Shariah principles. Smart contracts, as digital self-executing agreements, possess attributes that align strongly with Islamic ethical values, namely transparency, honesty, immutability, and accountability. By embedding Shariah-compliant rules directly into automated systems, smart contracts can verify donor identity, track milk distribution, and record milk kinship relationships with high precision and integrity, empowering Muslim families to make informed and secure decisions about milk donation and reception.

As Islamic finance, legal, and healthcare sectors increasingly adopt digital transformation, the application of smart contracts in human milk sharing marks a significant step toward technological solutions that preserve faith-based values. Far

from being a technical tool alone, smart contracts function as ethical infrastructures, capable of reconciling modern medical practices with the Shariah principles. The proposed framework can serve as a blueprint for healthcare institutions and religious authorities in Muslim-majority countries such as Malaysia, Indonesia and the Gulf states seeking to establish or formalize Shariah-compliant milk sharing programs. Health ministries could collaborate with Islamic authorities and technology developers to pilot blockchain-based milk kinship registries, particularly in neonatal intensive care units where donor milk need is highest.

The path forward, however, requires careful implementation, robust regulatory frameworks and continued collaboration with Shariah scholars to ensure theological integrity. Future studies should empirically evaluate the technical feasibility and Shariah acceptance of the proposed smart contract system through stakeholder engagement involving Muslim families, healthcare providers, Shariah scholars and technology developers. Cross-country comparative studies would further help identify how varying Islamic legal frameworks and national healthcare policies affect system implementation, while longitudinal studies examining blockchain-based kinship registries would provide critical real-world validation of the framework's Shariah compliance objectives.

In a nutshell, the integration of smart contracts into human milk sharing represents a significant and timely contribution to the growing field of Islamic bioethics and digital health. With careful implementation, robust regulatory frameworks and sustained collaboration between Shariah scholars and technologists, this approach offers a viable, trustworthy and equitable model for Shariah-compliant milk sharing ecosystems, which bridging tradition and innovation in service of both faith and the well-being of vulnerable infants in Muslim-majority societies.

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Conflicts of Interest

The author declares that there is no conflict of interest regarding the publication of this paper.

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