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Prophetic Guidance on Prayer Times: Integrating Hadith and Modern Astronomical Calculations

[Panduan Kenabian tentang Waktu Solat: Mengintegrasikan Hadis dan Pengiraan Astronomi Moden]

Mesbahul Hoque[1], Mohd Nor Adzhar Ibrahim[1]*, Mohd Zohdi Mohd Amin[1], Mansir Abubakar,[2] Mohd. Sobri Ellias[1]

1. Faculty of Quranic and Studies, Universiti Sains Islam Malaysia, Bandar Baru Nilai, Negeri Sembilan, Malaysia
2. Faculty of Computer and Mathematical Sciences, Universiti Teknologi MARA, Shah Alam, Selangor, Malaysia

* Corresponding Author: Mohd Nor Adzhar Ibrahim, Faculty of Quranic and Studies, Universiti Sains Islam Malaysia. Email: mnor.adzhar@usim.edu.my, Mobile: +6018-209 0102

Keywords:

Hadith; Prayer times; Islamic astronomy; Astronomical calculations; Modern technology; Islam.

ABSTRACT

Prayer (ṣalāh) times occupy a central position in Islamic worship, as the five daily prayers are prescribed at specific times determined by natural phenomena and guided by divine revelation. The Qur'an emphasizes the observance of prayer within fixed times, while the Sunnah of Prophet Muhammad (peace be upon him) provides detailed practical guidance for identifying these periods through observable signs such as dawn, sunrise, shadow length, sunset and the disappearance of twilight. Historically, Muslims relied on direct observation of celestial changes to determine prayer timings and Prophetic guidance served as the foundational framework for both individual worship and communal religious administration. With the advancement of science and technology, modern astronomical calculations have become increasingly important in determining precise prayer schedules. Mathematical models based on solar movement, geographic coordinates, atmospheric refraction and twilight angles now enable highly accurate prayer time calculations for different regions of the world. These methods are especially valuable in urban environments, regions with extreme latitudes and contexts where direct observation is difficult. Despite these advancements, variations remain among calculation methods adopted by Islamic institutions, creating debates regarding the balance between traditional observational approaches and computational precision. This study aims to explore how Prophetic guidance on prayer times can be effectively integrated with modern astronomical calculations in order to develop accurate and religiously sound prayer time systems. The research adopts a qualitative methodology and content analysis of classical Hadith sources, juristic discussions and contemporary scholarly studies on Islamic astronomy and digital prayer-time systems. Relevant sources were selected from peer-reviewed journals, classical texts and official institutional guidelines. The findings indicate that there is substantial compatibility between Hadith descriptions of prayer times and modern astronomical data. Prophetic signs provide the normative principles, while astronomical calculations offer operational precision and global applicability. This integration has improved consistency in prayer schedules, facilitated digital applications and strengthened worship management. However,

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challenges persist, including differing juristic interpretations, varying twilight-angle standards, regional environmental factors and overreliance on unverified mobile applications. The study concludes that a balanced integration of Hadith-based guidance and scientific calculation provides the most reliable framework for contemporary prayer time determination while preserving the spiritual and legal objectives of Islamic worship.

Kata Kunci:
Hadis; Waktu solat; Astronomi Islam; Pengiraan astronomi ; Teknologi moden; Islam.

ABSTRAK

Waktu solat menduduki kedudukan utama dalam ibadah Islam, kerana solat lima waktu ditetapkan pada waktu tertentu yang ditentukan oleh fenomena semula jadi dan dipandu oleh wahyu ilahi. Al-Quran menekankan pemeliharaan solat dalam waktu yang ditetapkan, manakala Sunnah Nabi Muhammad (saw) memberikan panduan praktikal yang terperinci untuk mengenal pasti tempoh ini melalui tanda-tanda yang boleh diperhatikan seperti subuh, terbitnya matahari, panjang bayang-bayang, terbenamnya matahari dan hilangnya senja. Dari segi sejarah, umat Islam bergantung pada pemerhatian langsung perubahan cakerawala untuk menentukan waktu solat dan panduan Nabi berfungsi sebagai kerangka asas untuk ibadah individu dan pentadbiran agama komunal. Dengan kemajuan sains dan teknologi, pengiraan astronomi moden menjadi semakin penting dalam menentukan jadual solat yang tepat. Model matematik berdasarkan pergerakan suria, koordinat geografi, pembiasan atmosfera dan sudut senja kini membolehkan pengiraan waktu solat yang sangat tepat untuk pelbagai kawasan di dunia. Kaedah ini amat berharga dalam persekitaran bandar, kawasan dengan latitud yang ekstrem dan konteks di mana pemerhatian langsung adalah sukar. Walaupun terdapat kemajuan ini, variasi masih wujud antara kaedah pengiraan yang diguna pakai oleh institusi Islam, mewujudkan perdebatan mengenai keseimbangan antara pendekatan pemerhatian tradisional dan ketepatan pengiraan. Kajian ini bertujuan untuk meneroka bagaimana panduan Nabi tentang waktu solat dapat disepadukan secara berkesan dengan pengiraan astronomi moden untuk membangunkan sistem waktu solat yang tepat dan kukuh dari segi agama. Kajian ini menggunakan metodologi kualitatif dan analisis kandungan sumber Hadis klasik, perbincangan perundangan dan kajian ilmiah kontemporari tentang astronomi Islam dan sistem waktu solat digital. Sumber yang berkaitan dipilih daripada jurnal berwasit, teks klasik dan garis panduan yang dikeluarkan oleh institusi rasmi. Penemuan menunjukkan bahawa terdapat keserasian yang ketara antara penerangan Hadis tentang waktu solat dan data astronomi moden. Panduan-panduan Nabi menyediakan prinsip normatif, manakala pengiraan astronomi menawarkan ketepatan operasi dan kebolehgunaan global. Integrasi ini telah meningkatkan konsistensi dalam jadual solat, memudahkan aplikasi digital dan memperkukuh pengurusan ibadah. Walau bagaimanapun, cabaran masih berterusan, termasuk tafsiran perundangan yang berbeza, piawaian sudut senja yang berbeza-beza, faktor persekitaran serantau dan sikap terlalu bergantung pada aplikasi mudah alih yang tidak disahkan. Kajian ini menyimpulkan bahawa penyepaduan seimbang panduan berasaskan Hadis dan pengiraan saintifik menyediakan rangka kerja yang paling boleh dipercayai untuk penentuan waktu solat kontemporari sambil memelihara objektif rohani dan perundangan ibadah Islam.

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1. Introduction

Prayer (*Ṣalāh*) is one of the five pillars of Islam and occupies a central place in Muslim spiritual, ethical and communal life. It is the most frequently performed obligatory act of worship, required five times daily and serves as a continuous reminder of submission to Allah, discipline and moral consciousness. Beyond its devotional dimension, prayer structures the daily routine of Muslims and reinforces spiritual awareness through recurring acts of remembrance. Because of its obligatory nature, the accurate determination of prayer times has always been a matter of major importance in Islamic jurisprudence and religious administration (Bahri & Hasibuan, 2024). Islamic worship is inherently time-bound. The Qur'an states that prayer has been prescribed for believers at fixed times, establishing a legal and spiritual framework in which acts of worship must be performed within designated temporal limits. The Sunnah further clarifies these timings by connecting them to observable celestial signs such as dawn, the sun's decline from the meridian, shadow length, sunset and the disappearance of twilight. Thus, prayer times are not arbitrary schedules, but divinely guided intervals rooted in the natural order. This combination of revelation and observable phenomena demonstrates Islam's integration of spirituality with cosmic regularity (Avissa et al., 2024).

Prophetic guidance played a decisive role in defining the beginning and ending times of each of the five daily prayers. Numerous Hadith describe Fajr beginning at true dawn, Dhuhr commencing after the sun passes its zenith, 'Asr linked to shadow extension, Maghrib at sunset and Isha' after twilight disappears. These narrations formed the basis of classical juristic discussions and practical worship systems across Muslim societies. For centuries, Muslims relied on direct visual observation and local expertise to determine these times, especially through mosque timekeepers and scholars trained in *ʿilm al-miqat* and *ʿilm al-falak* (Rojak & Fawzi, 2024).

The emergence of scientific astronomy significantly enhanced this process. Muslim scholars historically contributed to astronomy through observatories, trigonometry, solar tables and instruments such as the astrolabe, all of which supported prayer scheduling, qiblah determination and lunar calendar calculations. In the modern era, digital astronomy uses solar declination models, latitude–longitude coordinates, equation of time formulas and atmospheric refraction data to produce highly precise prayer schedules. Mobile applications, automated adhan systems and GPS-enabled software now make prayer times instantly available worldwide (Al Ayyubi et al., 2025). Despite these advances, differences remain between traditional observational methods and modern computational systems. Variations in twilight-angle standards for Fajr and Isha', juristic differences regarding 'Asr shadow ratios, latitude-related anomalies and inconsistencies among mobile applications have generated confusion among worshippers. In some contexts, users encounter several different prayer times for the same city, raising questions about accuracy, legitimacy and scholarly authority (Riza et al., 2025).

Accordingly, this study aims to explore how Prophetic guidance on prayer times can be integrated with modern astronomical calculations to create accurate and religiously sound systems. Specifically, it seeks to: (1) analyse Hadith-based principles of prayer timing, (2) explore contemporary astronomical calculation methods, (3) propose an integrated guideline for modern practice and (4) identify areas of convergence and disagreement. The study is guided by the following research questions: How do Hadith define prayer times? How do modern calculations operationalize these definitions? How can greater standardization be achieved? What challenges arise in harmonizing the two approaches?

The significance of this study lies in bridging classical Islamic knowledge with contemporary science. As Muslim societies increasingly rely on digital schedules and mobile applications, ensuring that these systems remain faithful to Prophetic guidance is essential. By integrating Hadith scholarship with astronomy, this research contributes to more reliable worship systems, stronger public trust and a deeper appreciation of the harmony between revelation and scientific precision.

2. Prophetic Hadith on Prayer Times

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The determination of the five daily prayers in Islam is fundamentally based on Prophetic Hadith, which provide practical explanations of the Qur'ānic command to observe prayer at fixed times. The Prophet Muhammad (peace be upon him) clarified the beginning and ending periods of each prayer through natural signs connected to the movement of the sun and changing light conditions (Al-Bukhari, (No:508- 521) 2002). These narrations became the foundation for classical Islamic jurisprudence and later astronomical calculations used in Muslim societies today (Saifullah et al., 2025).

The time of Fajr begins with the emergence of *fajr ṣādiq* (true dawn), as clearly distinguished in primary Hadith sources. The Prophet Muhammad (peace be upon him) said: "Do not be deceived by the adhan of Bilal or the vertical whiteness in the horizon until the dawn spreads horizontally" (Muslim, (no:1094) 2006). Classical commentators explain that *fajr kādhib* appears as a vertical column of light, while *fajr ṣādiq* spreads laterally across the horizon, marking the lawful beginning of prayer and fasting (al-Nawawī, 1996). These interpretations demonstrate the Prophetic precision in describing observable phenomena. Contemporary astronomical studies affirm that this horizontal illumination corresponds to the onset of true twilight before sunrise (Qulub et al., 2024).

The time of Dhuhr begins immediately after the sun passes its zenith (*zawāl*), as established in authentic Hadith. The Prophet (peace be upon him) said: "The time for Dhuhr begins when the sun passes its zenith…" (Muslim, (no:612) 2006). Classical hadith commentators explain that *zawāl* is identified by the moment when the sun declines from its highest point and shadows begin to lengthen after reaching their minimum. This explanation is detailed in the sharḥ literature, where al-ʿAynī (2001), al-Qasṭallānī (2008), and Ibn al-Mulaqqin (2009) clarify that the increase in shadow length signifies the definitive entry of Dhuhr time. Traditionally, this was observed through shadow tracking and sundials. In modern contexts, astronomy determines *zawāl* precisely using solar transit calculations, longitude, and the equation of time. This reflects the integration of Prophetic guidance with scientific precision in determining prayer times (Avissa et al., 2024).

The beginning of 'Asr (afternoon) prayer is based on Prophetic instructions regarding shadow length. In authentic narrations, the Prophet (peace be upon him) explained the prayer times through Jibrīl's guidance over two days, where the start of 'Asr was observed when the shadow of an object became equal to its length (Abū Dāwūd, (no: 393) 2009; al-Tirmidhī, (no: 149) 1998). Classical hadith commentators explain that this indication reflects the observable transition marking the entry of 'Asr time. Scholars such as Ibn Ḥajar al-ʿAsqalānī (2001) and al-Nawawī (1996) clarify that the increase of shadow after reaching its minimum signifies the beginning of the prayer. This understanding remains firmly grounded in Prophetic guidance. Contemporary digital prayer systems calculate 'Asr time using solar altitude equations based on shadow length ratios. The standard method determines 'Asr when an object's shadow equals its height, while another method calculates it when the shadow becomes twice the object's height. Astronomically, this is derived from the sun's altitude angle in relation to the observer's latitude and solar declination. Prayer-time applications convert these shadow ratios into precise solar position calculations, enabling accurate determination of 'Asr across different geographical locations and seasons. (Manzil & Amalia, 2024).

The time of Maghrib (sunset) begins immediately with the disappearance of the sun's disk below the horizon. Authentic Hadith sources consistently state that the Prophet (peace be upon him) instructed to begin Maghrib prayer and break the fast as soon as the sun has completely set (Abū Dāwūd, (no: 393) 2009; Muslim, (no:612) 2006). Classical hadith commentators clarify that this refers to the full disappearance of the solar disk, not residual light in the sky. Ibn Ḥajar al-ʿAsqalānī in *Fatḥ al-Bārī* (2001) explains that the legal ruling is based on the observable absence of the sun itself, even if twilight remains visible. Similarly, al-Nawawī in *Sharḥ Ṣaḥīḥ Muslim* (1996) emphasizes the immediacy of Maghrib time and its link to breaking the fast without delay. In modern practice, sunset timing can be calculated with high astronomical precision using solar geometry, making Maghrib one of the most consistently determined prayer times worldwide, subject only to minor variations in altitude and atmospheric refraction (Riza et al., 2025). Finally, Isha' (night prayer) begins with the disappearance of twilight after sunset. Authentic Hadith literature describes the start of this prayer when the evening glow fades from the sky (Muslim, (no:613) 2006). Classical hadith commentators explain that this twilight refers to the redness remaining in the western horizon after sunset. Al-Qasṭallānī in *Irshād al-Sārī* (2008) clarifies that the legal sign for Isha' is the complete disappearance of this red twilight, while earlier light is still considered part of Maghrib time. Similarly, al-ʿAynī in *ʿUmdat al-Qārī* (2001) discusses juristic differences regarding whether the ruling applies to the red twilight or full darkness, reflecting interpretive variation among scholars. These differences led to diverse positions in Islamic legal schools. In modern practice, astronomical calculations approximate Isha' time using solar depression angles between 15° and 18° below the horizon, ensuring consistency in digital prayer systems (Ramza et al., 2021).

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Overall, Prophetic Hadith established a dynamic system linking worship to observable cosmic signs. Modern astronomy has not replaced this framework; rather, it has translated these signs into measurable calculations suitable for contemporary global practice.

3. Modern Astronomical Calculation of Prayer Times

Modern astronomical calculation of prayer times represents the contemporary scientific application of classical Islamic principles governing the five daily prayers. While Prophetic guidance established prayer times through observable natural signs such as dawn, sunset and shadow length, advances in astronomy now allow these indicators to be translated into precise mathematical formulas. Contemporary prayer-time systems are widely used by Islamic institutions, mosques and mobile applications to generate accurate schedules for different locations and seasons (Rojak, 2021; Saad et al., 2022).

One of the most important variables in prayer-time computation is solar declination, which refers to the angular position of the sun north or south of the celestial equator throughout the year. Because the Earth's axial tilt changes the apparent position of the sun daily, solar declination directly affects sunrise, sunset and daylight length. Another key element is the equation of time, which measures the difference between apparent solar time and mean clock time caused by the Earth's elliptical orbit and axial tilt. These two variables are essential for determining local solar noon, from which Dhuhr and other prayer times are derived (Hasan, 2020). The calculation of Fajr and Isha' depends largely on twilight angle models. Since these prayers begin when the sun is below the horizon, astronomers use solar depression angles to estimate the appearance of dawn light and the disappearance of evening twilight. Different institutions adopt varying angles based on juristic interpretation and observational studies. For example, the Muslim World League commonly uses 18° for Fajr and 17° for Isha, while the Islamic Society of North America (ISNA) uses 15° for both. Other authorities such as the Egyptian General Authority of Survey and Umm al-Qura University employ alternative models (Raisal & Rakhmadi, 2020).

Geographic latitude and longitude significantly influence prayer times. Longitude determines the relationship between local time zones and solar noon, while latitude affects the angle of sunrise, sunset and twilight duration. Near the equator, daily variations are moderate; however, at higher latitudes, especially above 48°–60°, twilight may persist for extended periods during summer or disappear rapidly in winter. This creates challenges for calculating Fajr and Isha, leading scholars to adopt adjustment methods such as the middle-of-the-night rule, one-seventh of the night, or angle-based proportional methods (Noreddine & Nassim, 2024). Modern prayer schedules rely on computational algorithms that integrate astronomical equations with user location data, elevation, time zone and juristic preferences. These algorithms are embedded in mobile applications, mosque clocks, GPS devices and online calendars. Automated systems can instantly generate annual timetables with minute-level precision, greatly improving convenience for global Muslim communities (Al Ayyubi et al., 2025).

Despite technological sophistication, standardization differences remain a major issue. International bodies such as the Muslim World League (MWL), ISNA, Umm al-Qura, Karachi method and regional councils use different twilight angles and Asr shadow standards. Consequently, users may find several prayer times for the same city across different apps. While these variations reflect legitimate scholarly diversity, they can also create confusion among worshippers. Therefore, many researchers recommend combining astronomical precision with local scholarly authority to ensure both technical accuracy and religious legitimacy (Riza et al., 2025). In conclusion, modern astronomical calculations have transformed the determination of prayer times by converting Prophetic signs into measurable scientific parameters. When guided by sound jurisprudence, these systems provide an effective bridge between Islamic tradition and contemporary technological precision.

4. Integration of Hadith and Astronomical Calculations

The determination of prayer times in Islam represents one of the clearest examples of harmony between revelation and scientific observation. The Qur'an prescribes prayer at fixed times, while the Sunnah of Prophet Muhammad (peace be upon him) explains these times through observable natural signs such as dawn, solar decline, shadow length, sunset and twilight disappearance. In the contemporary world, these Prophetic indicators are increasingly translated into precise astronomical formulas. Rather than creating a contradiction between religion and science, modern scholarship demonstrates that astronomical calculations often function as technical extensions of Prophetic guidance (Avissa et al., 2024).

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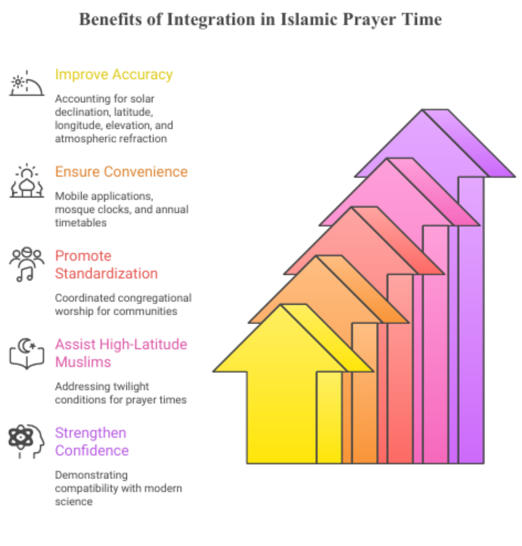
A key area of integration lies in the alignment between physical signs and astronomical data. The Hadith describe the beginning of Fajr as the appearance of *fajr ṣādiq* (true dawn), which modern astronomy associates with the first horizontal spread of twilight when the sun is below the horizon. Similarly, Dhuhr begins after the sun passes its zenith (*zawāl*), a moment that can be mathematically calculated through solar transit equations. Maghrib starts when the sun disappears below the horizon, while Isha' begins after twilight fades. These scriptural descriptions correspond closely with measurable celestial events, indicating that Prophetic teachings were rooted in natural realities that astronomy can quantify with greater precision today (Bahri & Hasibuan, 2024).

The compatibility analysis between Hadith and astronomy becomes especially clear when examining practical worship systems. Historically, Muslims relied on direct observation because it was the most accessible method available. Today, however, digital calculations can provide accurate prayer schedules for millions of users across diverse geographical contexts, including urban environments where horizon visibility is obstructed. Studies on digital prayer scheduling conclude that astronomical models preserve the essence of Prophetic guidance while increasing consistency and usability. Thus, computation should not be viewed as replacing the Sunnah but as operationalizing it through scientific tools (Rojak & Fawzi, 2024).

Another important dimension concerns juristic acceptance of calculation (*ḥisāb*). Classical scholars differed regarding the extent to which calculations could be used, particularly in matters such as lunar months and prayer times. In prayer-time determination, many jurists historically accepted mathematical estimation when observation was difficult or when specialists possessed reliable astronomical knowledge. Contemporary councils and religious authorities widely employ *ḥisāb* for prayer schedules because solar motion is predictable and measurable. Modern *fiqh* discussions therefore distinguish between using calculations as a legitimate tool and treating them as independent from revealed guidance. In most current Muslim-majority countries, official prayer timetables are already based on this integrated model (Riza et al., 2025).

The benefits of integration are substantial. First, it improves accuracy by accounting for solar declination, latitude, longitude, elevation and atmospheric refraction. Second, it ensures convenience through mobile applications, mosque clocks and annual timetables. Third, it promotes standardization for communities requiring coordinated congregational worship. Fourth, it helps Muslims living in high-latitude regions were twilight conditions complicate direct visual observation. Finally, integration strengthens confidence by showing that Islamic ritual guidance remains compatible with modern science (Jamaluddin, 2022). Figure below shows the benefits of integration in Islamic prayer times.



Nevertheless, challenges remain. Differences in twilight-angle standards for Fajr and Isha', distinct *madhhab* interpretations for Asr shadow ratios and inconsistencies among mobile applications can create confusion. Public discussions frequently show users noticing several prayer times for the same city depending on app settings or calculation method. This indicates that scientific precision must be accompanied by scholarly governance and local institutional guidance.

Ultimately, the integration of Hadith and astronomical calculations reflects the broader Islamic synthesis of *naqli* (revealed knowledge) and ‘*aqli* (rational inquiry). Prophetic Hadith provide the normative framework and spiritual meaning of prayer times, while astronomy provides measurable implementation. When responsibly combined, both traditions contribute to accurate worship, communal unity and renewed appreciation of Islam’s intellectual heritage. Contemporary scholarship increasingly recognizes that the future of prayer-time determination lies not in choosing between observation and calculation, but in harmonizing both within sound juristic principles.

5. Challenges in Integrating Hadith and Modern Prayer Time Calculations

Although modern astronomical calculations have significantly improved the determination of Islamic prayer times, several challenges continue to affect their consistency, legitimacy and public acceptance. The integration of Prophetic guidance with scientific computation is intellectually valuable, yet practical implementation often encounters methodological differences, institutional fragmentation, technological misuse and geographical complexities. These challenges demonstrate that precision alone does not automatically produce consensus or religious confidence (Rojak & Fawzi, 2024).

One of the most common issues is the variation in calculation methods used by institutions and software developers. Prayer times for Fajr and Isha’ depend on twilight-angle models, but different authorities adopt different solar depression values. For example, some organizations use 18°, while others use 15°, 17°, or fixed-minute offsets after sunset. Similarly, Asr time differs between juristic schools depending on whether the shadow of an object equals its length or twice its length. These methodological differences can result in prayer-time discrepancies of several minutes and in some cases much more, especially in northern latitudes (Bahri & Hasibuan, 2024). Closely related to this is the lack of global consensus. Different countries, councils and regional mosque networks often follow separate standards such as the Muslim World League (MWL), Islamic Society of North America (ISNA), Umm al-Qura, Karachi, or locally developed systems. While these differences may reflect legitimate scholarly diversity, they can create confusion for travellers, diaspora communities and global digital users. A Muslim moving between countries may encounter significantly different Fajr or Isha timings despite using the same city coordinates. The absence of a universally recognized framework limits uniformity in global worship administration (Al Ayyubi et al., 2025).

Another growing concern is the misuse of apps without scholarly verification. Many mobile applications provide convenient prayer schedules, but not all are developed under the supervision of qualified scholars or trained astronomers. Some apps use outdated databases, incorrect time zones, inaccurate geolocation settings, or hidden default calculation methods unfamiliar to users. Others fail to disclose whether they apply altitude correction, daylight-saving adjustments, or local mosque standards. As a result, users may unknowingly rely on inaccurate timings while assuming technological authority guarantees correctness (Jamaluddin, 2022). Therefore, a verified Islamic prayer-time application should meet several technical and religious criteria, including: (1) approval or consultation with recognized Islamic scholars, (2) use of accurate astronomical algorithms, (3) transparent disclosure of calculation methods and solar angles, (4) reliable GPS and time-zone synchronization, (5) support for local mosque or national religious authority settings, and (6) regular database and software updates to maintain accuracy and consistency.

Environmental and geographical variability also creates serious challenges. Traditional Hadith descriptions of prayer times rely on visible natural signs, yet weather conditions such as clouds, dust, pollution, humidity and urban light pollution may obscure dawn or twilight observations. Furthermore, latitude strongly affects the duration of twilight. In equatorial regions, dawn and dusk transition relatively quickly, whereas in high-latitude areas twilight may continue for long periods or not disappear fully during summer. This complicates Fajr and Isha determination and requires special adjustment methods such as one-seventh of the night, middle-of-the-night rules, or angle-based approximations (Avissa et al., 2024).

A further challenge is the over-reliance on automation. While digital tools increase convenience, many users no longer understand the Prophetic basis of prayer times or the scientific logic behind calculations. They may simply follow app notifications without knowing why times differ or how settings are selected. This passive

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dependence risks weakening Islamic literacy regarding worship timings and reduces awareness of the relationship between prayer and natural cosmic rhythms. Scholars increasingly argue that technology should assist worship rather than replace human understanding and informed judgment (Mutiara & Arrohmatan, 2024). Institutional trust is another important issue. In many Muslim communities, local mosques may follow timetables that differ from smartphone applications. When mosque announcements, printed calendars and apps show different times, ordinary worshippers may lose confidence in all systems. This challenge is particularly visible in Ramadan and congregational settings where timing precision is socially significant. Therefore, synchronization between official religious bodies and digital platforms is increasingly necessary (Riza et al., 2025).

Despite these challenges, they should be viewed as opportunities for improvement rather than barriers to integration. Transparent algorithms, clearer disclosure of methods, local customization, scholarly review boards and public education can significantly reduce confusion. Interdisciplinary cooperation between jurists, astronomers, software engineers and mosque authorities is essential for developing trustworthy prayer-time systems. In conclusion, the challenges surrounding prayer-time calculations are not evidence of conflict between Hadith and science. Rather, they reveal the complexity of translating sacred guidance into global digital practice. A balanced model that combines Prophetic teachings, scientific rigor and responsible technological governance remains the most sustainable path forward.

6. Necessity of integration

The determination of Islamic prayer times represents one of the clearest examples of the relationship between revelation and scientific reasoning in Islamic civilization. The Qur'an and Sunnah establish the obligation of performing prayer at appointed times, while astronomy provides the tools to identify these times accurately in changing geographical and seasonal contexts. This demonstrates the need for a balanced integration between *naqli* (revealed knowledge) and *aqli* (rational/scientific knowledge). Revelation defines the principles and boundaries, whereas science assists in operationalizing them. Contemporary studies emphasize that prayer times were historically observed through the movement of the sun, but modern mathematical astronomy has transformed these observations into calculable schedules that can be used globally (Rojak & Fawzi, 2024; Ayyubi et al., 2025).

This balance between revelation and science is particularly important because overdependence on either side creates problems. If one relies solely on literal observation without scientific assistance, determining prayer times in urban environments, cloudy regions, polar zones, or high-rise cities becomes difficult. Conversely, if computational models are treated as autonomous authorities without reference to juristic principles, errors may occur in defining twilight angles, horizon assumptions, or local legal customs. Research on Fajr prayer time, for example, shows significant differences in adopted solar depression angles ranging from -14° to -20°, reflecting the need to harmonize empirical observation with *fiqh* interpretation (Abdul Niri et al., 2021).

Technology therefore should be viewed as a supportive tool rather than a replacement for religious scholarship. Mobile applications, automated calendars, GPS-based prayer alerts and AI-powered scheduling systems have made access to prayer times easier than ever. However, these technologies merely implement human-selected methodologies. They cannot independently decide jurisprudential matters such as which twilight standard to adopt, how to treat mountainous terrain, or whether local custom overrides generalized calculations. Studies on digital prayer-time systems note that many users assume app outputs are unquestionably accurate, despite hidden methodological differences in algorithms and databases (Rojak & Fawzi, 2024; Jamaluddin, 2023).

The tension between the authority of classical scholars and computational models should not be framed as a conflict. Classical jurists established foundational legal principles based on scriptural evidence and observable celestial signs. Modern astronomers and programmers extend these principles into practical computational tools. Thus, algorithms should function under scholarly supervision, not in competition with it. Recent scholarship on Islamic astronomy argues that digital authority must be repositioned under the framework of traditional knowledge so that technological convenience does not displace juristic legitimacy (Ayyubi et al., 2025).

The ethical and jurisprudential implications are equally significant. First, inaccurate prayer times may affect the validity or preferred timing of worship. Second, commercial apps may prioritize user growth over

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methodological transparency. Third, data collection practices in some digital services raise privacy concerns when geolocation data are continuously tracked. Fourth, algorithmic centralization without scholarly oversight may marginalize legitimate madhhab diversity (Faiz & Awaliyah, 2023). Therefore, ethics in Islamic digital tools must include accuracy, transparency, privacy protection and respect for jurisprudential plurality.

7. Recommendations

i. Develop a standardized global algorithm framework

International Islamic organizations and countries should collaborate to develop a global algorithm framework for prayer-time calculations. This framework should clearly define technical parameters such as solar depression angles, altitude corrections, atmospheric refraction assumptions, and special rules for extreme locations such as polar regions. For example, countries like Malaysia and Indonesia could agree on a standard range for dawn calculation (e.g., 18° or 19° solar depression), while allowing users to select different juristic methods based on recognized schools of thought. Similarly, in high-latitude regions such as northern Europe, the framework could provide specific fallback models when twilight does not disappear. Rather than enforcing a single rigid opinion, the system should offer standardized, approved options with clear scholarly justification, enabling consistency while preserving juristic diversity and scientific accuracy in global prayer time determination.

ii. Strengthen collaboration between scholars and astronomers

A sustainable model for prayer-time determination requires the establishment of interdisciplinary councils involving jurists (*fuqaha*), astronomers, software engineers, and data scientists. In such a structure, jurists are responsible for evaluating scriptural evidence and ensuring compliance with Islamic legal principles, while astronomers provide accurate calculations of solar positions and twilight conditions. Software engineers and data scientists contribute by developing reliable algorithms and ensuring transparency, usability, and consistency across digital platforms. Recent studies consistently show that integrating Islamic jurisprudence with astronomical science produces more accurate and credible outcomes than working in isolated disciplinary silos (Mutiara & Arrohmatan, 2024). This collaborative framework also helps reduce methodological discrepancies in digital prayer applications and strengthens public trust in modern Islamic timekeeping systems by aligning religious authenticity with scientific precision.

iii. Improve transparency in Islamic apps

Every prayer-time application should clearly disclose its calculation methodology in simple language, including the solar angle used, coordinate source, daylight-saving adjustment, update frequency, and issuing authority. Users should also be allowed to choose recognized standards or local mosque timetables instead of relying on hidden default settings. For example, widely used apps such as Muslim Pro, IslamicFinder, and Athan (IslamicFinder) are among the most popular global applications and are generally considered reliable because they provide selectable calculation methods (e.g., Muslim World League, ISNA, Umm al-Qura) and GPS-based location accuracy (IslamicFinder, 2024; Muslim Pro, 2024). Studies note that such flexibility improves usability but can also lead to variation in results if users do not understand settings (Riza et al., 2025). Advantages include accessibility, multiple juristic options, and global synchronization, while disadvantages include hidden default assumptions and lack of algorithm transparency. Therefore, greater standardization and disclosure are essential.

iv. Enhance education in Islamic astronomy

Mosques, universities, and Islamic institutions should actively promote literacy in Islamic astronomy so that communities understand the scientific foundations of prayer schedules. Basic public education can reduce blind dependence on mobile applications and instead foster informed and critical trust in digital tools (Hoque et al., 2019). Educational programs should be designed in simple and practical formats, explaining how sunrise, sunset, twilight phases, longitude, latitude, and seasonal changes affect the timing of each daily prayer. For example, learners can be shown how a change in latitude affects the length of daylight and therefore alters prayer time intervals in different countries. By linking religious practice with observable astronomical phenomena, such education strengthens both spiritual awareness and scientific understanding, ensuring that users can verify app outputs rather than accept them uncritically.

v. Establish a unified Islamic time authority system

At regional or global levels, a dedicated authoritative body similar to international standards agencies should be established to coordinate verified prayer-time data, issue periodic standard updates, and certify trustworthy Islamic applications. Such an institution could function as a central reference point for harmonizing calculation methodologies, particularly in areas where juristic and astronomical differences exist. National religious councils would retain their local autonomy in issuing rulings and adapting to community needs, while still contributing data and feedback to a shared international platform. For example, countries could upload their officially adopted calculation parameters, which would then be integrated into a global database used by app developers and researchers. This approach would improve consistency, reduce discrepancies between applications, and enhance public confidence in digital prayer systems while maintaining respect for regional scholarly diversity and legal traditions. In summary, the recommendations emphasize improving global consistency and reliability in prayer-time determination by integrating Islamic jurisprudence with modern astronomy and technology. A standardized global algorithm framework is needed to define key parameters such as solar angles, altitude corrections, and extreme-location rules while still allowing juristic diversity. Strengthened collaboration between scholars, astronomers, and technologists is essential to ensure accuracy and alignment between religious principles and scientific methods. Islamic applications should improve transparency by clearly disclosing calculation methods and allowing users to select different standards. Education in Islamic astronomy should be expanded to build public understanding and reduce overdependence on apps. Finally, a unified Islamic time authority system is recommended to coordinate data, certify applications, and harmonize standards globally while respecting regional scholarly differences and ensuring trust in digital prayer systems.

8. Conclusion

Modern astronomical calculations have significantly enhanced the precision, accessibility and global standardization of prayer time determination. Through mathematical modeling, satellite positioning systems, digital applications and automated scheduling software, Muslims today can access accurate prayer times instantly regardless of geographical location. This is particularly valuable in urban settings, regions with obstructed horizons and high-latitude areas where direct observation may be difficult. Nevertheless, scientific tools should be understood as instruments that serve the Prophetic framework rather than replace it. Hadith remains the normative source that defines the meaning and boundaries of prayer times, while astronomy provides technical methods for implementing those principles with greater efficiency.

The integration of hadith and astronomy also illustrates the broader harmony between *naqli* (revealed knowledge) and *aqli* (rational inquiry) in Islamic intellectual tradition. Revelation provides guidance, values and legal authority, while scientific reasoning contributes empirical measurement and practical solutions. When these two dimensions operate together, they strengthen both religious authenticity and functional accuracy.

Despite these advancements, challenges remain, including methodological differences in twilight angles, lack of global standardization, overreliance on unverified mobile applications and limited public understanding of Islamic astronomy. Addressing these issues requires continued collaboration among hadith scholars, jurists, astronomers and technology developers. The future of prayer-time determination lies not in choosing between revelation and science, but in integrating them responsibly. *Naqli* provides the sacred framework, while *aqli* supplies measurable precision. Technology should remain an instrument serving worship, guided by scholars and refined by scientists. If transparency, collaboration and standardization are prioritized, the Muslim world can develop a trustworthy and unified system that preserves tradition while benefiting from modern innovation.

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