

## The Integrating Precision Genomic Strategies and Islamic Ethical Perspectives in Stunting Prevention: Focus on the Growth Hormone-IGF-1 Pathway

## Integrasi Strategi Genomik Presisi dan Perspektif Etika Islam dalam Pencegahan Stunting: Fokus pada Jalur Hormon Pertumbuhan-IGF-1

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### Abstract

Stunting remains one of the major chronic nutritional problems in Indonesia. The national prevalence of stunting has decreased from 37.2% in 2013 to 19.8% in 2024; however, this figure is still above the World Health Organization threshold (<20%) and has not yet reached the national target of 14%. The interaction of nutritional, environmental, and genetic factors influences stunting. Genetic variations within the Growth Hormone–Insulin-like Growth Factor One pathway play a significant role in regulating linear growth in children; disruptions in this pathway can increase vulnerability to stunting. In addition, the majority of Indonesia's population adheres to Islam, making religious values a strategic potential for strengthening health interventions. This review article examines the integration of scientific approaches, focusing on genetics and Islamic values, in stunting prevention by highlighting polymorphisms in the IGF1, IGF1R, and GHR genes and their relevance to the principles of *maqāsid al-sharī'ah*, particularly *hifz al-nasl* (protection of lineage). The analysis is conducted using a descriptive-analytical approach based on recent scientific literature and Islamic references, including the Qur'an, prophetic traditions, and scholarly exegesis. The findings indicate a strong alignment between scientific approaches and Islamic teachings, including the importance of adequate nutrition during pregnancy, exclusive breastfeeding, consumption of lawful, nutritious food, genetic screening efforts consistent with the values of divine decree, and vitamin D supplementation to support Insulin-like Growth Factor One levels. This integration has the potential to enhance community acceptance of stunting-prevention programs, strengthen moral and spiritual motivation, and support the achievement of national stunting-reduction targets. Thus, an approach that combines precise genomics and Islamic values may serve as a contextual and sustainable strategy in shaping a generation that is healthy, intelligent, and spiritually resilient.

**Keywords:** Stunting, Genetics, GH-IGF1, *Maqāsid al-Sharī'ah*, *Hifz al-Nasl*

### Abstrak

Stunting masih menjadi salah satu masalah gizi kronis utama di Indonesia. Prevalensi stunting nasional telah menurun dari 37,2% pada tahun 2013 menjadi 19,8% pada tahun 2024; namun angka ini masih berada di atas ambang batas yang ditetapkan oleh World Health Organization (<20%) dan belum mencapai target nasional sebesar 14%. Stunting dipengaruhi oleh interaksi antara faktor gizi, lingkungan, dan faktor genetik. Variasi genetik pada jalur hormonal Growth Hormone–Insulin-like Growth Factor One berperan penting dalam pengaturan pertumbuhan linier pada anak; dalam praktiknya, gangguan pada jalur ini dapat meningkatkan kerentanan terhadap stunting. Selain itu, mayoritas penduduk Indonesia beragama Islam, sehingga nilai-nilai keagamaan memiliki potensi strategis untuk memperkuat intervensi kesehatan. Artikel tinjauan ini bertujuan untuk mengkaji integrasi pendekatan ilmiah yang berfokus pada aspek genetik dan nilai-nilai Islam dalam pencegahan stunting, dengan menyoroti polimorfisme gen IGF1, IGF1R, dan GHR serta keterkaitannya dengan prinsip *maqāsid al-sharī'ah*, khususnya *hifz al-nasl* (perlindungan keturunan). Analisis dilakukan menggunakan pendekatan deskriptif-analitis berdasarkan literatur ilmiah terkini dan sumber-sumber keislaman, termasuk Al-Qur'an, hadis Nabi, dan tafsir para ulama. Hasil kajian menunjukkan adanya keselarasan yang kuat antara pendekatan ilmiah dan ajaran Islam, seperti pentingnya kecukupan gizi selama kehamilan, pemberian ASI eksklusif, konsumsi makanan yang halal dan bergizi, upaya skrining genetik yang tetap selaras dengan nilai takdir ilahi, serta suplementasi vitamin D untuk mendukung kadar Insulin-like Growth Factor One. Integrasi ini berpotensi meningkatkan

penerimaan masyarakat terhadap program pencegahan stunting, memperkuat motivasi moral dan spiritual, serta mendukung pencapaian target nasional penurunan stunting. Dengan demikian, pendekatan yang menggabungkan genomik presisi dan nilai-nilai Islam dapat menjadi strategi yang kontekstual dan berkelanjutan untuk membentuk generasi yang sehat, cerdas, dan tangguh secara spiritual.

**Kata Kunci:** Stunting, Genetik, GH-IGF1, Maqāṣid al-Sharī'ah, Hifz al-Nasl



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## Introduction

Stunting is a chronic nutritional disorder characterized by a deviation in height-for-age below minus two standard deviations from the median of the World Health Organization reference population. This condition generally results from prolonged nutritional deficiency, recurrent infections, or a combination of both, particularly during the first 1,000 days of life, which span from pregnancy through 2 years of age. [1]. Its impact extends beyond impaired physical growth, affecting cognitive development, reducing productivity in adulthood, and increasing the risk of degenerative diseases such as diabetes and cardiovascular disorders. [2]. Globally, Development Initiatives (2021) reported that stunting remains a major indicator of childhood nutritional problems in many countries, including Indonesia. Although the national stunting prevalence has decreased from 37.2% in 2013 to 19.8% in 2024, this figure is still above the threshold set by the World Health Organization (<20%) and has not yet reached the national target of 14% [3].

Various interventions have been implemented by the Government of Indonesia, including nutrition-specific programs such as micronutrient supplementation and the promotion of exclusive breastfeeding, as well as nutrition-sensitive efforts such as improving sanitation, expanding access to clean water, and strengthening health education. [4]. However, the effectiveness of these programs is often hindered by social, cultural, and behavioral factors. Limited nutritional literacy, inappropriate dietary patterns, and resistance to behavioral change remain significant challenges. Therefore, a holistic prevention strategy is needed, one that not only focuses on medical and nutritional aspects but also integrates values aligned with the beliefs and norms of the local community.

In line with the need for a more holistic approach, stunting can be understood as a condition far more complex than merely the result of nutritional deficiencies and infections. Genetic factors contribute to individual susceptibility, causing children with certain predispositions to respond differently to nutritional interventions [5]. From biological and environmental perspectives, stunting also emerges through the interaction of chronic malnutrition, recurrent infections, and suboptimal environmental quality, along with various non-nutritional determinants that influence growth [6]. Recent evidence from Indonesian children demonstrates that certain genetic polymorphisms can significantly contribute to the risk of stunting, indicating that genetic susceptibility should be considered alongside nutritional and environmental factors [7]. This complexity becomes even more apparent in the socioeconomic and environmental disparities across regions in Indonesia, where uniform intervention strategies do not always produce optimal outcomes. This situation underscores the importance of a comprehensive understanding of the combined biological, environmental, and sociocultural factors involved in stunting prevention [8].

In addition to nutrition and environmental factors, genetic components also contribute to the risk of stunting through the Growth Hormone–Insulin-like Growth Factor One hormonal pathway, which regulates

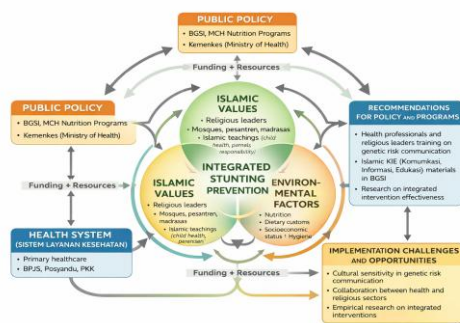
linear growth in children [9,10]. Gene polymorphisms in Insulin-like Growth Factor One, Insulin-like Growth Factor One Receptor One, or Growth Hormone Receptor may influence both the production and effectiveness of Insulin-like Growth Factor One, thereby disrupting growth signaling and increasing susceptibility to stunting, particularly when accompanied by malnutrition or recurrent infections [9,11].

The focus on the GH-IGF1 pathway in this review is grounded in strong biological evidence. It is also relevant within an Islamic ethical framework that emphasizes human responsibility (*taklif*) to safeguard life and prevent the emergence of a physically weak generation (*dhurriyyatan di'āfan*), in line with the maqāshid al-sharī'ah principles of *hifz al-nafs* (protection of life) and *hifz al-nasl* (protection of progeny). Biologically, this pathway is a principal regulator of linear growth, controlling chondrocyte proliferation, collagen synthesis, and epiphyseal plate elongation [12,13]. Moreover, IGF-1 is highly sensitive to changes in nutritional status, inflammation, and vitamin D levels, making it an ideal indicator for understanding the interaction between environmental and genetic factors [14–16]. Genetic variations within this pathway have been shown to influence IGF-1 production, responsiveness to growth hormone, and susceptibility to stunting, highlighting its relevance as a potential biomarker of risk [17,18].

Indonesia has strategic potential to integrate religious values into stunting prevention programs, given that the majority of its population (87.2%, approximately 207 million people) adheres to Islam [19]. Islamic teachings place strong emphasis on the welfare of future generations, as reflected in the principles of Maqāshid al-Sharī'ah, particularly Hifz al-Nasl, which underscores parents' responsibility to safeguard their children's health, nutrition, and well-being. [20].

Faith-based approaches hold substantial potential to strengthen public health interventions by shaping behavioral norms, enhancing intrinsic motivation, and reinforcing moral responsibility. [21]. Evidence from behavioral science also shows that delivering health education through religious frameworks improves adherence to healthy practices, including dietary habits, hygiene, and parenting behaviors. [22]. Considering that Islam plays a central role in the daily lives of Indonesian communities, integrating scientific messages, including genetic information, into religious values may enhance the effectiveness and community acceptance of stunting prevention programs.

The integration of Islamic values in stunting prevention can strengthen moral and spiritual motivation. [3], enhance the acceptance of health messages delivered through religious channels such as Friday sermons or community study gatherings [4] and encourage consistent healthy behaviors. Moreover, this approach has the potential to improve nutritional practices and increase community participation in supporting child growth and development [23].



**Figure 1.** Conceptual framework of Islamic value-based interventions for stunting prevention in Indonesia.

Given the multifactorial nature of stunting, experts are increasingly advocating for a “precision prevention” approach, an emerging paradigm that tailors public health interventions based on biological risk factors, environmental exposures, and socio-cultural contexts [24,25]. Genetic markers within the GH-IGF1 pathway may serve as early indicators for identifying children who are more vulnerable to growth impairments, thereby enabling more targeted nutritional, behavioral, and community-based interventions [26]. When combined with strategies grounded in cultural and religious values, this approach has the potential to enhance both the effectiveness and community acceptance of stunting prevention programs in Indonesia [5].

This review article examines the role of Islamic-based interventions in preventing stunting in Indonesia, covering theological foundations, empirical evidence, and implementation strategies. This review is expected to provide a conceptual and practical framework for preventive programs that are contextual, sustainable, and

acceptable to Muslim communities, while also supporting national efforts to reduce stunting and the development of a healthy, intelligent, and spiritually strong generation. The conceptual framework of this study is summarized in Figure 1.

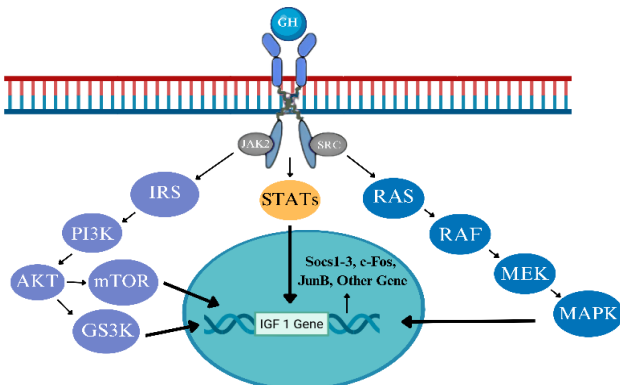
## Discussion

This review utilized secondary data derived from previously published scientific and Islamic scholarly sources. Biomedical literature on childhood stunting and genetic variations in the GH-IGF1 pathway was retrieved from international academic databases, including PubMed, Scopus, ScienceDirect, and Google Scholar. The materials included peer-reviewed original research articles, systematic reviews, and meta-analyses focusing on human studies involving GH1, IGF1, IGF1R, and GHR gene polymorphisms and their associations with linear growth or stunting outcomes. In addition to scientific sources, Islamic references were used to support the ethical and theological framework of this review. These materials consisted of the Qur'an, authenticated hadith collections, classical tafsir literature, contemporary Islamic bioethics books, and articles published by recognized Islamic scholars and institutions. All materials were selected to support an integrative analysis between biomedical evidence and Islamic perspectives on child growth, parental responsibility, and the protection of progeny (hifz al-nasl).

This study employed a descriptive-analytical literature review approach based on previously published biomedical and Islamic scholarly sources. Scientific literature related to childhood stunting and genetic variations within the GH-IGF1 pathway (GH1, IGF1, IGF1R, and GHR genes) was retrieved from PubMed, Scopus, ScienceDirect, and Google Scholar using Boolean combinations of keywords such as "IGF1 polymorphism," "GH-IGF1 signaling pathway," "childhood stunting," "hifz al-nasl," and "Islamic bioethics child health." Islamic references were obtained from classical and contemporary tafsir literature, authenticated hadith collections, and Islamic bioethics publications addressing child welfare, parental responsibility, and hifz al-nasl. Biomedical articles published between 2015 and 2025 were included if they were peer-reviewed, involved human subjects. They reported growth-related outcomes, while non-peer-reviewed articles, animal studies, and conference abstracts were excluded. Relevant data were extracted and thematically analyzed to synthesize molecular mechanisms of the GH-IGF1 axis, population-specific genetic susceptibility to stunting, and their integration with Islamic ethical principles using a narrative synthesis approach.

## GH-IGF1 Molecular Pathway in Linear Growth

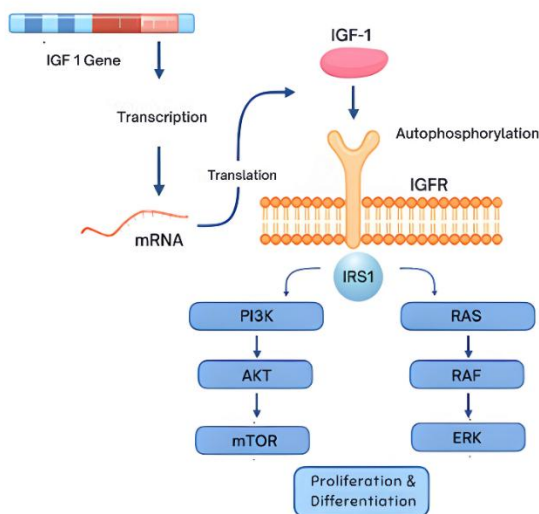
GH binds to the GHR, which activates Janus Kinase 2 (JAK2) and triggers three main pathways: Signal Transducers and Activators of Transcription (STATs) to stimulate IGF1 gene expression, Insulin Receptor Substrate-Phosphoinositide 3-Kinase/Protein Kinase B (IRS-PI3K/Akt) for protein synthesis and cellular metabolism, and the SHC adaptor protein (SHC)/Growth factor receptor-bound protein 2 (Grb2)-Mitogen-Activated Protein Kinase (MAPK) pathway for cell proliferation and differentiation. All three act synergistically in growth, metabolism, and cell maturation, demonstrating that GH functions not only through IGF-1 but also exerts direct effects [27,28]. A simplified illustration is shown in Figure 2.



**Figure 2.** The growth hormone (GH) signaling pathway and its role in initiating childhood growth. Adapted from (Lu et al., 2019).

The IGF-1 hormone binds to the IGF1R receptor, triggering a conformational change and autophosphorylation of the  $\beta$  subunit tyrosine kinase domain, thereby activating the receptor and recruiting IRS1 [29–31]. This activation transmits signals through two main pathways: PI3K/AKT/mechanistic Target of

Rapamycin (mTOR) for protein synthesis and anti-apoptosis, and MAPK/Extracellular signal-Regulated Kinase (ERK) for cell proliferation [32]. A simplified illustration is shown in Figure 3.



**Figure 3.** IGF-1 activation pathway and its contribution to bone growth and development. Adapted from (Werner, 2023).

The combination of these two pathways is essential for bone cell growth and differentiation. Disruptions in IGF1R receptor activation or its downstream signaling pathways have been associated with short stature and an increased risk of stunting, particularly in individuals with IGF-1 deficiency resulting from related genetic mutations. Therefore, this pathway plays a crucial role in the linear growth process of children [33–35].

IGF-1 binds to IGF1R in chondrocytes and osteoblasts, activating the PI3K/Akt and MAPK/ERK pathways, which trigger cell proliferation, collagen synthesis, and the extension of the proliferative phase of the epiphyseal plate, critical aspects of bone growth [36,37]. Furthermore, studies have shown a correlation between low IGF-1 levels and children's HAZ scores, indicating a high risk of stunting [38,39].

### Variations in the GH–IGF1 Pathway and Their Association with Stunting Risk

Genetic studies have reinforced the role of the GH–IGF1 pathway, showing that variations in its genes can influence IGF-1 expression. Such changes in expression can affect height and increase the risk of growth disorders, including stunting [40,41]. A more detailed overview is presented in Table 1.

Evidence from countries such as China and Poland indicates that polymorphisms in the GH1, IGF1, IGF1R, and GHR genes contribute significantly to variations in linear growth among children. These findings reinforce the understanding that growth impairment is not solely determined by nutritional factors but also arises from complex interactions between genetic architecture and environmental exposures [40–42]. In line with this, several studies across Asia have identified additional genes involved in key biological pathways related to growth, including hormonal signaling within the GH–IGF1 axis, paracrine factors in the FGF, BMP, and WNT pathways, extracellular matrix molecules involved in chondrogenesis, and intracellular RAS–MAPK signaling pathways that regulate cell proliferation and differentiation [35]. There are even reports suggesting that conditions such as obesity may be associated with short stature, although this evidence requires further confirmation; a study of obese adolescents in Indonesia found only a weak association between short stature and the GHSR1R rs292216 variant [45]. Interestingly, a recent study in Indonesia also found that a GHSR polymorphism, specifically the G57G variant with the CT genotype, was significantly associated with stunting in young children. This finding reinforces that, in addition to the core components of the GH–IGF1 axis, variations in related hormonal pathways such as the ghrelin receptor may also influence growth regulation [7].

Nevertheless, research on GH–IGF1 genetic variation within Indonesian populations remains limited, creating a knowledge gap regarding how local genetic profiles may influence susceptibility to stunting. This situation underscores the need for integrative, population-specific research to inform more targeted intervention strategies. Based on Table 1, among the genetic variations reviewed, only rs35766 in the IGF1

gene has been specifically reported to be directly associated with stunting, particularly in the Indonesian pediatric population [43]. This genetic variant is known to influence plasma IGF-1 levels, with the codominant AG genotype associated with lower hormone levels and a higher risk of stunting. Therefore, rs35766 can be considered a potential risk marker for stunting in the Indonesian context, pending further validation.

**Table 1.** List of Growth-Related Gene Variants in the GH-IGF-1 Pathway Based on Population Studies

Genetic Variation	Related Gene	Functional Effect	Phenotypic Association	Population/Country	Ref.
rs151263636 & rs371953554	GH1	Missense variant; possible deleterious effect (predicted)	Found in 2/186 children with growth hormone deficiency (GHD) / short stature potential contributor to the short stature phenotype	Polish	[40].
rs2684788	IGF1R	Reducing IGF-1 levels relatively through genetic expression regulation	Short stature / Idiopathic short stature (ISS)	China (Jiangxi)	[41].
rs4292454	GHR	Suspected to affect GH receptor expression regulation	Weak association with ISS	Europe	[42].
rs12515480 & rs6873545	GHR	Protective effect against GH deficiency (GHD)	Reduced risk of GH deficiency	China	[41].
rs35766	IGF1	Influences IGF-1 levels	Stunting	Indonesia	[38]

Nevertheless, it is essential to emphasize that current evidence regarding genetic susceptibility to stunting in Indonesian populations remains limited. Most available studies are observational and primarily report statistical associations rather than causal relationships. Consequently, the presence of specific genetic variants, including IGF1 rs35766, should not be interpreted as direct determinants of stunting but rather as potential modifiers of individual vulnerability that interact with nutritional, environmental, and infectious factors. Consistent with the principles of precision public health, genetic information is intended to refine risk stratification rather than replace population-wide interventions, which remain the cornerstone of stunting prevention [24]. Importantly, the majority of stunting cases are still preventable through well-established universal strategies, such as adequate maternal nutrition, exclusive breastfeeding, appropriate complementary feeding, infection control, and improvements in sanitation and living conditions, regardless of genetic background [18,44]. Therefore, genetic screening should be considered only after sufficient validation and always as a complementary component of comprehensive public health approaches.

In considering the potential role of genetic insights in stunting prevention, it is important to balance the anticipated benefits of a precision-genetic approach against the practical and economic challenges associated with its implementation in a low-resource public health setting. While genetic screening has proven useful in identifying individuals at increased risk for certain heritable conditions and has been incorporated into public health programs in high-income settings, the evidence underscores significant concerns regarding feasibility, cost, and ethical implications when applied at the population level. Genomic population health screening models suggest that cost-effectiveness is typically achievable for high-penetrance disorders when testing costs are reduced, and clinical interventions are available, but these models also highlight substantial financial and infrastructural requirements that may limit broad implementation in resource-strained environments [44].

Moreover, genetic screening and testing raise ethical and social considerations, including potential issues of privacy, discrimination, and equitable access, which are particularly salient when genetic information is used beyond clinical diagnosis into predictive screening of asymptomatic populations [45]. In low- and middle-income countries, strengthening research ethics governance and ensuring inclusive participation are essential to ensure that the benefits of precision medicine research and genetic testing are distributed fairly and respectfully across diverse populations [46]. These factors imply that while genomic knowledge may offer scientific insight into growth-regulation pathways, routine population-wide genetic screening for stunting in Indonesia is currently of limited feasibility and uncertain cost-effectiveness, given competing demands for proven interventions such as nutritional supplementation, sanitation improvements, and poverty reduction.

Taken together, these factors indicate that while genomic knowledge may provide valuable scientific insight into growth-regulation pathways, routine population-wide genetic screening for stunting in Indonesia is currently of limited feasibility and uncertain cost-effectiveness, particularly in light of competing priorities for well-established interventions such as nutritional supplementation, sanitation improvements, and poverty reduction. Therefore, a more realistic role for genetic approaches may lie in targeted risk stratification or research aimed at identifying subgroups of children most likely to benefit from intensified interventions, rather than replacing established nutritional and environmental strategies. This approach acknowledges the multifactorial nature of stunting and positions genetic information as a complementary tool that enhances, rather than supplants, conventional public health measures. Future research should prioritize empirical evaluation of whether integrating genetic risk assessment with existing stunting prevention programs improves outcomes, and whether such integration is ethical, sustainable, and acceptable to communities and stakeholders in Indonesia.

Before genetic screening for stunting risk can be considered for broader public health application, a rigorous validation phase is essential. Current evidence on GH-IGF1 pathway polymorphisms in Indonesian populations remains preliminary and is largely derived from candidate-gene association studies with limited sample sizes. Future research should therefore prioritize large-scale, population-representative studies, including genome-wide association studies (GWAS), to identify robust genetic signals while adequately capturing genetic diversity across Indonesian ethnic groups. Such approaches are fundamental within the framework of precision public health, as they allow more reliable estimation of effect sizes, clarification of gene-environment interactions, and reduction of false-positive associations [24]. Until sufficient validation is achieved through nationally coordinated genomic initiatives, genetic screening should remain within the research domain and be positioned strictly as a complementary tool to established universal stunting prevention strategies, rather than as a standalone public health intervention [65].

### **Integrative Approaches to Stunting Prevention: Combining Islamic Values and Scientific Evidence**

In Islam, the utilization of genetic information aligns with the principles of effort (*ikhtiar*) and human responsibility. Genetic factors are understood as part of *qadar* (divine predestination), the divine decree determined by Allah since eternity, yet there remains room for effort through *takdir muallaq*, which can be altered by human endeavor and prayer. [46]. Thus, although genetics influences a person's condition, Islam emphasizes that behavior, morality, and personal qualities are still shaped by effort and righteous deeds.

Genetic factors, as part of a person's physical and spiritual makeup, can be seen as part of *qadar*, the decree predetermined in *Lauh al-Mahfuz* since primordial times. Nevertheless, Islam teaches that not all destiny is absolute; there is *takdir muallaq*, which can still be changed through effort and prayer, and *takdir mubram*, which represents Allah's absolute decree [46]. Therefore, even if an individual inherits certain genetic traits, they still have the capacity to strive in shaping their behavior and character.

Beyond the *maqāṣid al-sharī'ah* framework, additional principles of *uṣūl al-fiqh* provide important ethical guidance for evaluating both the intention and implementation of genetic screening for stunting risk. The principle of *al-umūr bi maqāṣidihā* (actions are judged by their objectives) emphasizes that the permissibility of genomic screening depends fundamentally on its intended purpose—namely, to enhance early nutritional support and preventive care, rather than to label, stigmatize, or socially differentiate children based on genetic risk. Furthermore, the principle of *dar' al-mafāsīd muqaddam 'alā jalb al-maṣāliḥ* (preventing harm takes precedence over pursuing benefit) requires careful consideration of potential adverse consequences, such as psychological distress, misuse of genetic data, or inequitable access to follow-up interventions. Within contemporary Islamic bioethical discourse on genetic testing, these principles function as normative safeguards to ensure that emerging genomic technologies are applied in ways that uphold human dignity and social justice, particularly in Muslim communities where religious values play a central role in health-related decision-making [49].

Genetic screening results may also raise ethical questions within Islamic moral reasoning regarding parental responsibilities when heightened vulnerability to stunting is identified. While parents are encouraged to pursue actions that promote their children's well-being, Islamic ethics links moral obligation to both intention and capacity (*istithā'ah*). Accordingly, intensified nutritional interventions informed by genetic risk do not automatically become obligatory (*wājib*), particularly when they impose substantial financial or social burdens. In such contexts, these efforts may be better understood as strongly recommended (*sunnah mu'akkadah*), consistent with the principles of hardship removal (*raf' al-ḥaraj*) and proportional benefit.

The implications of this understanding are significant in Islamic education, as it instills the belief that humans are not solely determined by genetics but also by their efforts in life, the cultivation of good character, and the enhancement of personal qualities through al-akhlaq al-karimah (righteous deeds) [46]. The application of genetic information and scientific knowledge in accordance with Islamic values can thus serve as a foundation for implementing interventions, as illustrated in Table 2.

**Table 2.** Scientific Integration, Islamic Teachings, and Interventions in Preventing Stunting in Children

No	Scientific Review	Religious Perspective	Intervention
1	Genetic screening plays a crucial role in health management by enabling disease prediction, early diagnosis, personalized prevention, and precision therapy through individual risk analysis [47,48].	QS. An-Nisa: 9 → The duty to safeguard weak offspring	Genetic screening of gene polymorphisms can serve as a preventive measure to avert stunting, representing an effort to safeguard offspring from becoming a weak generation through nutritional interventions.
2.	Children with stunting generally have lower IGF-1 levels than the standard value for healthy children, which is $\geq 28.54$ ng/ml. Administration of vitamin D at doses $\leq 1000$ IU/day has been shown to significantly increase IGF-1 levels. Additionally, intervention durations of up to $\leq 12$ weeks also demonstrated a meaningful effect on raising IGF-1 levels [49,50].	QS. Ar-Ra'd: 11 → Allah does not change the condition of a people until they change what is within themselves.	Nutritional interventions via vitamin D supplementation at doses $\leq 1000$ IU/day may increase IGF-1 levels, which is expected to improve stunting, in accordance with QS. Ar-Ra'd: 11, which emphasizes the importance of making efforts to bring about positive change.
3.	Studies have shown that exclusive breastfeeding has a protective effect against stunting, particularly when mothers are over 30 years old during pregnancy, and there is a significant association between exclusive breastfeeding and the incidence of stunting in children aged 24–60 months [51,52].	QS. Al-Baqarah: 233 → The obligation to breastfeed and provide for the child.	Islam strongly encourages exclusive breastfeeding for a full two years as a form of support for the child's natural growth.
4.	Stunting in young children is associated with low consumption of animal protein, and a variety of animal sources (milk, meat, fish, eggs) is more effective in preventing stunting than a single type alone; this pattern was also observed in the Minggir Community Health Center area, suggesting that increasing local animal protein intake is recommended [53,54].	QS. Al-Baqarah: 168 → Consuming what is halal and wholesome.	Community education on the importance of choosing halal, nutritionally balanced foods, including increasing intake of animal protein from safe, affordable local sources, as a measure to prevent stunting.
5.	The dual burden of malnutrition in children in Indonesia is influenced by dietary transitions, highlighting the need for interventions that emphasize parental education on the risks of an unbalanced diet [55,56].	QS. Al-A'raf: 31 → The prohibition of excess in eating and drinking.	Promoting balanced nutrition rather than excess. Nutrition education in stunting interventions is important to prevent both undernutrition and overnutrition.

Based on the integration of scientific findings and Islamic principles presented in Table 2, there is a strong alignment between scientific approaches and religious teachings in stunting prevention. Islamic principles emphasizing adequate nutrition from pregnancy, exclusive breastfeeding, consumption of halal and nutritionally balanced foods, and moderation (avoiding excess) are consistent with recent research showing that comprehensive interventions, including parental understanding, animal protein intake, and nutrition education, effectively reduce stunting prevalence [53,54,57,58]. In line with this, the Indonesian government has implemented programs such as Free Nutritious Food (MBG), Supplementary Feeding (PMT), the National 1000 Days Movement (HPK), and Posyandu to improve nutrition and parental knowledge. The integration of scientific approaches, religious values, and public policy makes stunting prevention more effective, sustainable, and grounded in local wisdom.

Of the many frequently quoted verses, particularly “Indeed, Allah will not change the condition of a people until they change what is in themselves” (Quran, Ar-Ra’d: 11), it is often interpreted narrowly as a call for individual effort. However, a broader reading within its socio-ethical context highlights the collective dimension of change, emphasizing communal responsibility and structural transformation. In the context of stunting prevention, this verse can be understood as encouraging not only personal behavioral change but also collective action to improve the social and environmental determinants of child development, such as access to nutritious food, clean water, adequate sanitation, and maternal health services. From this perspective, community empowerment, including the ability to advocate for supportive policies and equitable health infrastructure, becomes a religiously grounded imperative. Thus, Islamic ethical teachings reinforce the notion that sustainable stunting prevention requires coordinated community efforts alongside individual and household interventions.

### **Integration of Islamic Values and Scientific Approaches in Stunting Prevention: Synergies and Challenges**

The integration of scientific evidence and Islamic values in stunting prevention represents more than an effort to enhance community acceptance; it offers the potential to develop intervention models that are more ethical, equitable, and holistic than purely biomedical approaches. Within Islamic teachings, the concept of *ikhtiar* emphasizes individual and collective responsibility to pursue preventive actions that safeguard health and well-being, including adequate nutrition, child care, and environmental hygiene [63, 64, 65]. This principle is strongly aligned with public health evidence demonstrating that active parental and caregiver engagement in nutrition and health interventions improves behavioral adherence and sustains long-term intervention outcomes [66, 67, 68].

However, the theological concept of *qadar* may be misinterpreted as fatalistic if not accompanied by appropriate educational framing. Without contextual explanation, such interpretations may reduce motivation to engage in preventive behaviors. Studies in health communication and behavioral science indicate that culturally sensitive education and risk communication can effectively address this barrier by emphasizing that acceptance of divine decree does not negate the obligation to strive for health and well-being [69,70,71]. In this context, integrating Islamic teachings with scientific explanations can strengthen intrinsic motivation while acknowledging the multifactorial nature of stunting, including environmental, socioeconomic, and genetic determinants.

Beyond improving acceptance, the integration of Islamic values contributes added ethical and social value to stunting prevention strategies. Core Islamic principles such as *’adl* (justice) and *ihsan* (benevolence) support an approach that prioritizes human dignity, reduces stigma, and promotes equitable access to health services, particularly among vulnerable and marginalized populations [72,73,74]. This perspective complements contemporary public health frameworks that emphasize fairness, inclusivity, and community empowerment as essential components of effective nutrition interventions.

Concrete implementation of this integrative approach can be realized through unified health education programs rather than fragmented messaging. For example, training modules for *posyandu* cadres may combine practical guidance on maternal and child nutrition, complementary feeding practices, and sanitation improvement with Islamic moral narratives that reinforce parental responsibility and collective care [75,76,77]. Similarly, Friday sermon (*khutbah*) materials can contextualize stunting prevention as a shared moral obligation, linking scientific recommendations with Qur’anic and prophetic teachings that emphasize nurturing children and safeguarding future generations [78,79,80].

Such an integrative model positions scientific knowledge and religious values as mutually reinforcing elements within stunting prevention programs. Rather than replacing established nutrition and environmental interventions, this approach enhances their ethical grounding, social legitimacy, and sustainability within predominantly Muslim communities, thereby supporting more comprehensive and context-sensitive public health strategies in Indonesia.

### **Implementation Challenges and Opportunities for Strengthening Interventions**

On the other hand, resistance toward genetic testing persists in some Muslim communities, where such practices are perceived as interfering with *qadar* or raising ethical and theological concerns, particularly in contexts with limited genetic literacy [81,82]. However, in the Indonesian context, religious authority plays a crucial role in shaping public acceptance of biomedical innovations. The Majelis Ulama Indonesia, through its Fatwa No. 35/2013 on genetic engineering and its products, explicitly states that genetic technologies are permissible (*mubah*) as long as they serve the public benefit (*ma’slahah*) and do not cause harm (*lā ḍarar wa lā*

*dirār*). This position provides a normative Islamic framework that supports the ethical use of genetic testing for health purposes. When genetic screening is framed within the principles of *maqāṣid al-sharī'ah*, particularly *hifz al-nafs* (protection of life) and *hifz al-nasl* (protection of progeny), communities demonstrate greater openness and acceptance toward such interventions [83–85]. Integrating genetic education with Islamic values has shown potential benefits in improving parental awareness, health-related behaviors, and acceptance of stunting prevention programs [23], especially when supported by collective deliberation involving scientists, religious scholars, and government authorities [82,84].

Incorporating Islamic values into stunting research not only adds religious significance but also facilitates the acceptance of genetically-based prevention efforts within Muslim communities. In Islam, the concept of *hifz al-nasl*, as part of *maqāṣid al-sharī'ah*, emphasizes safeguarding offspring from various weaknesses, including growth disorders caused by nutritional deficiencies and genetic factors. This principle is explicitly reflected in Surah An-Nisa, verse 9, which warns Muslims not to leave behind generations that are physically and mentally weak. In line with this, Islam strongly supports exclusive breastfeeding, the consumption of halal and *thayyib* (wholesome) foods, and parental education as concrete forms of *ikhtiar* in maintaining the quality of future generations.

These values can be harmonized with modern scientific approaches, for example, through genetic screening of IGF1 gene polymorphisms, which have been scientifically proven to contribute to growth hormone regulation and stunting risk [64]. Supported by credible scientific literature and authentic religious sources, this integration provides a strong ethical foundation. Understanding that *qada* and *qadar* do not negate human effort helps shift community perspectives from viewing genetic testing as interference with divine will to understanding it as a responsibility to safeguard children's health, thereby promoting both scientific acceptance and religious awareness.

Furthermore, the implementation of genetic screening, including the identification of IGF1 polymorphisms and other growth-related genes, aligns with Indonesia's national agenda through the Biomedical and Genome Science Initiative (BGSi), which aims to strengthen genomic research capacity and expand the use of genetic data for public health. The BGSi program not only facilitates the development of national genome sequencing and biobank infrastructure but also promotes innovations in precision therapy and risk-based prevention strategies tailored to the Indonesian population [86]. With this genomic infrastructure in place, screening for IGF1 gene variants can be conducted with greater accuracy, standardization, and sensitivity to the genetic diversity of Indonesian communities. The integration of genetic screening, *maqāṣid al-sharī'ah* values, and national policy through BGSi offers substantial opportunities to strengthen stunting prevention interventions that are more precise, ethically grounded, and broadly acceptable to the public.

From a policy perspective, the Biomedical and Genome Science Initiative (BGSi) constitutes a strategic national program initiated by the Kementerian Kesehatan Republik Indonesia to incorporate genomic science into Indonesia's health system, focusing on strengthening genome sequencing capacity, biobank infrastructure, and genomic data utilization for public health and precision medicine [87]. Official releases from the Ministry of Health describe BGSi as Indonesia's first national initiative to promote the use of genomic information for disease prevention, early detection, and personalized health strategies, including expanded whole-genome sequencing efforts and standardized data governance across multiple regional hubs [87]. The initiative is framed within the broader health system transformation agenda to improve preventive services and leverage genomic technologies to support risk stratification and evidence-based interventions. In this context, identifying growth-related genetic variants, such as IGF1 polymorphisms, can be integrated into long-term stunting-prevention strategies aligned with national genomic research infrastructure and policy goals.

## Conclusions and Future Directions

Stunting is a complex issue involving interactions among environmental, genetic, and spiritual factors. From a genetic perspective, variations in the GH-IGF1 pathway, such as genetic variations in IGF1 and IGF1R, play a crucial role in determining stunting risk. In parallel, Islamic values provide an ethical and spiritual foundation to strengthen the role of families in stunting prevention through the concepts of *hifz al-nasl* and *ikhtiar*. The integration of science and Islam represents a strategic and contextual approach, particularly for the Muslim communities in Indonesia. Genetic education delivered through a religious framework has the potential to enhance awareness, increase acceptance of interventions, and improve the effectiveness of

stunting prevention programs. Further research is recommended to explore the relationship between genetic variations in the GH-IGF1 pathway and responses to nutritional and vitamin D interventions in longitudinal studies within local populations.

Future research should also examine community adherence and behavioral changes following educational interventions that integrate genetic screening with religious values. It is essential to understand whether faith-based educational approaches can increase willingness to undergo genetic testing, strengthen parental engagement in childcare and nutrition practices, and reduce misconceptions about qadar. Such studies would provide scientific evidence on the extent to which religiously grounded education can produce sustainable health behavior changes within Muslim communities. In addition, further research is needed to evaluate the effectiveness of vitamin D interventions in populations that have undergone genetic screening, particularly among children carrying GH-IGF1 pathway polymorphisms associated with growth disorders. Measuring changes in IGF-1 levels before and after targeted vitamin D supplementation—based on individual genetic profiles—will help determine whether this precision approach yields better outcomes compared to standard interventions. These findings could support the development of precision nutrition models that integrate genetic information, micronutrient optimization, and culturally grounded health education to strengthen stunting prevention efforts in Indonesia.

## Conflict of Interest

All authors declared no conflicts of interest.

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## Supplementary Materials

Not applicable.

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