Analysis of Global Infant Mortality Rate Status Based on World Health Statistics 2015

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Abstract

[Objective] To analyze the global status of infant mortality rate (IMR) and explore systematic and precise prevention and control strategies.

[Methods] Based on IMR and the proportional composition of major causes of death provided in the World Health Statistics 2015, the achievement of Millennium Development Goals was evaluated using the magnitude of IMR decline from 1990 to 2013. The patterns of IMR changes were analyzed through comparative analysis between 2000 and 2013, and bivariate Pearson correlation analysis was used to determine the correlation between IMR and the "infectious to non-infectious disease ratio" and per capita GDP.

[Results] By 2013, 40 (20.62%) of the 194 World Health Organization member states had achieved the IMR Millennium Development Goal. Comparisons between 2000 and 2013 showed statistically significant differences in IMR across the six continents and in the low and high mortality groups ($P<0.05$), but not in the medium mortality group ($P>0.05$). The "infectious to non-infectious disease ratio" showed no statistically significant differences in the medium and low mortality groups ($P>0.05$), but a significant difference in the high mortality group ($P<0.05$). Comparisons of the "infectious to non-infectious disease ratio," IMR, and average decline between low and medium, and medium and high mortality groups showed statistically significant differences ($P<0.05$). Regional differences in global IMR were evident, with Africa having the highest mean IMR, Europe the lowest, Oceania, South America, and North America in the middle range, and Asia gradually approaching the middle level. The global IMR proportion was 68.87% in 2000 and 73.74% in 2013. The IMR proportion in each country showed a strong negative correlation with U5MR ($r_{2000}=-0.893$, $r_{2013}=-0.809$, $P<0.05$). IMR in each country showed a strong positive correlation with the "infectious to non-infectious disease ratio" ($r_{2000}=0.913$, $r_{2013}=0.901$, $P<0.05$) and a weak negative correlation with per capita GDP ($r_{2000}=-0.488$, $r_{2013}=-0.467$, $P<0.05$).

[Conclusion] Reducing global IMR remains a long and arduous task. Prevention and control efforts should focus on Africa and Asia. Implementation of systematic and precise prevention and control strategies is recommended.

Full Text

Preamble

Analysis of Global Infant Mortality Rate Based on "World Health Statistics 2015"

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Abstract

[**Objective**] To analyze the current status of global infant mortality rate (IMR) and explore systematic and precise prevention and control strategies. [**Methods**] Based on IMR and the proportional composition of major causes of death from *World Health Statistics 2015*, we assessed Millennium Development Goal (MDG) achievement using IMR reduction magnitude from 1990–2013. We analyzed IMR change patterns through comparative analysis of 2000 and 2013 data, and employed bivariate Pearson correlation analysis to examine relationships between IMR and the "infectious to non-infectious disease ratio" and per capita GDP. [**Results**] By 2013, 40 (20.62%) of 194 WHO member states had achieved the IMR MDG. Comparisons between 2000 and 2013 revealed statistically significant differences in IMR across six continents and between low- and high-mortality groups ($P < 0.05$), but no significant difference in the moderate-mortality group ($P > 0.05$). The "infectious to non-infectious disease ratio" showed no significant difference between low- and moderate-mortality groups ($P > 0.05$), but a significant difference in the high-mortality group ($P < 0.05$). Significant differences existed between low/moderate and moderate/high mortality groups in both the "infectious to non-infectious disease ratio" and average IMR reduction magnitude ($P < 0.05$). Global IMR exhibited marked regional variation, with Africa showing the highest mean, Europe the lowest, and Oceania, South America, and North America at intermediate levels, while Asia gradually approached the intermediate level. The global IMR proportion was 68.87% in 2000 and 73.74% in 2013, with national IMR proportions highly negatively correlated with under-five mortality rate (U5MR) ($r = -0.893$, $r = -0.809$, $P < 0.05$). National IMR was highly positively correlated with the "infectious to non-infectious disease ratio" ($r = 0.913$, $r = 0.901$, $P < 0.05$) and weakly negatively correlated with per capita GDP ($r = -0.488$, $r = -0.467$, $P < 0.05$). [**Conclusion**] Reducing global IMR remains a formidable and long-term task. Prevention and control efforts should focus on Africa and Asia. Systematic and precise prevention and control strategies are recommended.

Keywords: Infant mortality rate; World health statistics; Infectious diseases;

GDP per capita

1 Introduction

At the turn of the new century, global leaders made an epoch-making commitment through the *United Nations Millennium Declaration*, establishing eight Millennium Development Goals to be achieved by 2015, with Goal 4 aiming to reduce child mortality by two-thirds between 1990 and 2015. Research predicted that only 27 developing countries would achieve this target. In reality, by 2013, just 46 (23.71%) of 194 WHO member states had achieved the U5MR MDG. WHO Fact Sheet No. 290 (May 2015) acknowledged that the world would likely fail to meet this target by 2015. Some studies suggest that increased health investment is crucial for further reducing global child mortality, providing reference recommendations for future prevention and control measures. China' s experience demonstrates that increased health investment promotes IMR decline, yet Tanzania saw no IMR reduction despite increased expenditure—warranting attention. In 2013, China' s IMR accounted for 79.17% of U5MR (86.67% in urban areas, 77.93% in rural areas), indicating that IMR constitutes a substantial proportion of U5MR. Studying IMR change patterns thus holds practical significance for reducing U5MR. What, then, is the current global IMR status? This question merits serious attention.

2 Literature Review

Numerous studies have identified per capita gross national product and GDP as important influencing factors for IMR in most countries and regions. The percentage of national public health expenditure relative to GDP, per capita public health expenditure, and government health expenditure all correlate negatively with IMR. In China, when per capita government health expenditure grew faster than per capita GDP, IMR declined rapidly. Brazil' s federal government assumed financing responsibility through conditional cash transfer programs, investing in health and education for impoverished children. Colombia implemented fiscal decentralization, devolving healthcare expenditure and improving health insurance systems. Uganda employed decentralization pathways to provide public goods such as medical services. Collectively, this evidence indicates that increased health investment helps reduce IMR.

Where should governments direct increased health investment? Malawi achieved the IMR MDG, with infant immunization representing a key success factor. In Central America, regions with diphtheria-pertussis-tetanus vaccine coverage saw child mortality decline significantly faster than the global average. Cross-national research shows a strong negative correlation between physicians per 1,000 population and IMR. Japan achieved the world' s lowest infant mortality in 1991 through universal maternal-child health handbooks, universal health insurance, effective public health education, and excellent healthcare social support systems. Argentina failed to meet MDG targets, primarily due to insufficient reduction in neonatal mortality. Brazil achieved MDG success through technological advances in neonatal intensive care units and resources to save or prolong newborn lives. China' s promotion of neonatal resuscitation technology effectively reduced neonatal asphyxia incidence and mortality. Health investment encompasses various interventions, particularly neonatal care measures, health workforce development, health facility investment, and health education.

In 73 countries experiencing armed conflict, IMR correlated with peace agreement implementation and higher-level democracy. During the Iraq War, IMR rose rapidly then declined quickly after the war' s conclusion. Under the Soviet Union, healthcare was nearly free, but after its dissolution, inability to pay for healthcare led to dramatically reduced quality and a sudden halt in IMR decline in Kyrgyzstan. After the founding of the People' s Republic of China, IMR declined substantially due to increased policy support. This evidence collectively demonstrates that political instability and social unrest impede IMR reduction.

In Ethiopia, greater household wealth correlates with lower child mortality. Among 19 OECD countries, family cash allowances reduced IMR. In the United States, a strong positive correlation exists between poverty rate and IMR. Reducing wealth disparities and eliminating poverty benefit IMR reduction. In the first decade of the new century, global food price increases significantly adversely affected nutritional status in developing countries, particularly least-developed nations, increasing infant and child mortality. Food and nutrition constitute basic conditions for child survival.

The U.S. National Center for Health Statistics reported that while U.S. IMR declined in 2013, racial and ethnic disparities persisted, with Black women' s IMR double that of white women. Adult literacy rate and maternal literacy correlate with IMR. In Nigeria, male infant mortality is higher; in India, female infant mortality is higher—both linked to harmful customs and gender discrimination. Global U5MR shows marked regional variation. Before 1978, Japan exhibited clear regional differences, which were eliminated after effective health and medical service improvements. Racial equality, educational equality, gender equality, and regional equality reflect social progress, with equalized rights benefiting infant health and survival.

Research shows that maternal smoking and solid fuel use increase infant mortality risk by 71%. Studies demonstrate that a 1 ppb increase in atmospheric CO concentration over one week increases IMR by 0.0032‰, while a 1 μg/m^3 increase in PM10 increases IMR by 0.24‰. Surface water quality deterioration shows an initial increase then decrease in IMR, with moderate pollution being most dangerous. In the new era of global economic development, environmental protection and pollution reduction help safeguard life and health rights.

In summary, IMR influencing factors constitute a complex system involving political, economic, health, educational, environmental, agricultural, familial, and customary domains, with numerous, intertwined, and complex factors exhibiting particularities across different countries and regions. Existing literature extensively examines IMR influencing factors but rarely investigates IMR status patterns. Therefore, based on IMR and major cause-of-death composition data for 194 WHO member states from *World Health Statistics 2015*, we assessed MDG achievement, analyzed IMR status, combined per capita GDP data from data.un.org to evaluate economic growth-IMR correlations, and re-examined IMR influencing factors to further explore prevention and control strategies, providing reference for national and departmental decision-making.

3.1 Data Sources

Data on IMR, U5MR for 1990, 2000, and 2013, and proportional composition of major causes of death for 2000 and 2013 for 194 WHO member states were obtained from *World Health Statistics 2015*, downloaded from the WHO website on December 20, 2015. Mean U5MR values for six continents were derived from literature sources. Per capita GDP data for 194 countries in 2000 and 2013 were obtained from data.un.org, retrieved on January 15, 2016.

3.2 Methods

(1) Millennium Development Goal Assessment Method
IMR reduction magnitude was calculated as:
IMR Reduction (%) = (2013 IMR - 1990 IMR) ÷ 1990 IMR × 100%
Achievement of the IMR MDG was defined as reduction magnitude 2/3 (66.67%).

(2) Infectious to Non-infectious Disease Ratio
Infectious diseases included AIDS, diarrhea, measles, malaria, pneumonia, neonatal sepsis, and other major causes reported in *World Health Statistics 2015*. Non-infectious diseases included preterm birth, birth asphyxia, congenital anomalies, accidental injuries, and other major causes; other diseases were excluded. For a given country and year, with live births X, infant deaths Y, infectious disease deaths M, and non-infectious disease deaths N:
Infectious disease mortality rate = (M ÷ X) × 1000‰
Infectious disease proportion = (M ÷ Y) × 100%
Non-infectious disease mortality rate = (N ÷ X) × 1000‰
Non-infectious disease proportion = (N ÷ Y) × 100%

Since infectious disease proportion ÷ non-infectious disease proportion = infectious disease cases ÷ non-infectious disease cases = infectious disease mortality rate ÷ non-infectious disease mortality rate, we simplified this to the "infectious to non-infectious disease ratio" to compare magnitude and temporal changes, thereby judging shifts in infant causes of death.

(3) Regional Classification
Countries were classified by geographic location into six continents: Africa (54 countries), Asia (46), Oceania (15), North America (24), South America (12),

and Europe (43).

(4) IMR Grouping
Referencing the UN Statistics Division' s "Millennium Development Goals 2014 Progress Chart," UNICEF and WHO' s "Levels and Trends in Child Mortality (2014 Report)," and global U5MR grouping analyses, we categorized IMR as: high mortality (IMR > 40‰), low mortality (IMR 10‰), and moderate mortality (40‰ IMR > 10‰).

(5) Statistical Analysis
Average IMR change 2000–2013 (‰) = (2013 IMR - 2000 IMR) ÷ 13, reflecting average annual IMR change (negative values indicate average reduction). IMR proportion refers to IMR as a percentage of U5MR: IMR proportion = current year IMR ÷ current year U5MR × 100%; global IMR proportion = global mean IMR ÷ global mean U5MR × 100%.

Due to lack of 1990 cause-of-death classification data in *World Health Statistics 2015*, we compared complete 2000 and 2013 data using paired-sample t-tests. Independent-sample t-tests compared low/moderate and moderate/high mortality groups and six continents, with variance homogeneity tests first; if variances were unequal, corrected t-tests were used. Bivariate Pearson correlation analysis examined relationships between the "infectious to non-infectious disease ratio" and IMR, IMR proportion and U5MR, and per capita GDP and IMR. Statistical processing used SPSS 17.0, with $P < 0.05$ considered statistically significant. In correlation analysis, non-significant results indicated no relationship; significant results were judged by |r|: |r| 0.95 = significant correlation; 0.95 > |r| 0.8 = high correlation; 0.8 > |r| 0.5 = moderate correlation; 0.5 > |r| 0.3 = low correlation; |r| < 0.3 = very weak relationship, considered non-correlated.

4.1 Millennium Development Goal Achievement

Using 1990 IMR as baseline, by 2013, 40 countries had achieved the IMR MDG, representing 20.62% of WHO member states. These included 18 European, 14 Asian, 4 African, 2 South American, and 2 North American countries. The top 10 countries by reduction magnitude were: Maldives (87.61%), Estonia (83.64%), Macedonia (82.42%), Luxembourg (78.08%), Czech Republic (77.34%), Peru (77.17%), Brazil (76.07%), Serbia (75.83%), China (74.17%), and Slovenia (73.86%). One hundred fifty-four countries (79.38%) failed to achieve the IMR MDG, including 50 African, 32 Asian, 25 European, 22 North American, 15 Oceanian, and 10 South American countries. The bottom 10 countries by reduction magnitude were: Niue (-73.95%), Zimbabwe (-9.13%), Lesotho (-5.04%), Swaziland (-0.90%), Botswana (6.68%), Brunei (10.64%), Mauritania (13.75%), Seychelles (14.08%), St. Vincent and the Grenadines (16.10%), and Central African Republic (16.65%).

4.2 Cross-sectional Comparison: 2000 vs. 2013

Except for Seychelles, Brunei, and Niue, 191 countries (98.45% of WHO member states) showed varying degrees of IMR decline. Statistically significant differences in IMR between 2000 and 2013 were observed across all six continents .

Comparisons between 2000 and 2013 revealed statistically significant IMR differences in low- and high-mortality groups, but not in the moderate-mortality group. The "infectious to non-infectious disease ratio" showed no significant difference between low- and moderate-mortality groups, but a significant difference in the high-mortality group .

Table 1 Six-continent IMR comparison between 2000 and 2013 (‰)

Table 2 Global IMR (‰) and "infectious to non-infectious disease ratio" comparison, 2000–2013

4.3 Longitudinal Comparison: 2000 and 2013

In 2000, statistically significant differences existed between low/moderate (F = 77.290, P = 0.000, t = 17.274, P = 0.000) and moderate/high (F = 71.133, P = 0.000, t = 19.291, P = 0.000) mortality groups. The "infectious to non-infectious disease ratio"also showed significant differences between low/moderate (F = 43.218, P = 0.000, t = 11.076, P = 0.000) and moderate/high (F = 62.903, P = 0.000, t = 15.609, P = 0.000) groups.

In 2013, statistically significant differences persisted between low/moderate (F = 101.241, P = 0.000, t = 15.716, P = 0.000) and moderate/high (F = 16.479, P = 0.000, t = 15.458, P = 0.000) mortality groups. The "infectious to non-infectious disease ratio" showed significant differences between low/moderate (F = 56.665, P = 0.000, t = 11.466, P = 0.000) and moderate/high (F = 7.741, P = 0.006, t = 12.679, P = 0.000) groups.

Using 2000 IMR grouping, average IMR reduction 2000–2013 was: low-mortality group 0.16‰ ± 0.09‰, moderate-mortality group 0.63‰ ± 0.40‰, and high-mortality group 2.13‰ ± 1.03‰, with significant differences between low/moderate (F = 34.516, P = 0.000, t = 10.045, P = 0.000) and moderate/high (F = 40.256, P = 0.000, t = 11.525, P = 0.000) groups.

4.4 Regional Distribution of IMR

The distribution of high-, moderate-, and low-mortality countries in 1990, 2000, and 2013 showed regional variation, with low-mortality countries concentrated in Europe and high-mortality countries in Africa. Over time, low-mortality countries gradually increased while high-mortality countries decreased .

Table 3 Regional distribution of IMR among 194 countries

4.5 IMR Proportion

In 2000, national IMR proportions ranged from 44.51% to 91.24%, with a global average of 68.87% (39.49‰/57.34‰). Seventy-eight countries (40.21%) had proportions < 80% (5 low-, 7 moderate-, 66 high-mortality), while 116 countries (59.79%) had proportions 80% (39 low-, 61 moderate-, 5 high-mortality). IMR proportion was highly negatively correlated with U5MR (r = -0.893, P = 0.000).

In 2013, national IMR proportions ranged from 56.62% to 92.45%, with a global average of 73.74% (25.55‰/34.65‰). Sixty-eight countries (35.05%) had proportions < 80% (10 low-, 16 moderate-, 42 high-mortality), while 126 countries (64.95%) had proportions 80% (54 low-, 67 moderate-, 5 high-mortality). IMR proportion remained highly negatively correlated with U5MR (r = -0.809, P = 0.000). Six-continent IMR proportions are shown in .

Table 5 IMR proportion by continent

4.6 Correlation Between IMR and "Infectious to Non-infectious Disease Ratio"

IMR was highly positively correlated with the "infectious to non-infectious disease ratio" in both 2000 (r = 0.913, P = 0.000) and 2013 (r = 0.901, P = 0.000). Correlations by mortality group are shown in .

Table 6 Correlation between IMR and "infectious to non-infectious disease ratio"

4.7 Correlation Between Per Capita GDP and IMR

Per capita GDP was weakly negatively correlated with IMR across 194 countries in both 2000 (r = -0.488, P = 0.000) and 2013 (r = -0.467, P = 0.000). Six-continent correlations are shown in .

Table 7 Six-continent correlation analysis between per capita GDP and IMR

5.1 Significance of Global IMR Status Analysis

IMR is a crucial indicator of national/regional economic, political, health, and educational development, and protecting child health represents an important government function. While global U5MR has generally declined, achieving a 49% reduction from 1990 to 2013, 76.29% of countries failed to achieve the U5MR MDG. Our results show that only 20.62% of countries achieved the IMR MDG, indicating that reducing global IMR remains a formidable task. IMR constituted a substantial proportion of U5MR in both 2000 and 2013, with all continents except Africa showing proportions above 80% in 2013. The strong negative correlation between IMR proportion and U5MR suggests that as U5MR declines, IMR proportion gradually increases. Therefore, effectively reducing

IMR currently contributes meaningfully to global U5MR reduction, and studying global IMR patterns holds practical significance for further U5MR reduction.

5.2 Basic Patterns of Global IMR Status

Over time, 98.45% of WHO member states showed IMR decline, with significant reductions across all six continents. Low-IMR countries increased while high-IMR countries decreased. IMR declined significantly in low- and high-mortality groups but not in the moderate-mortality group, suggesting that moderate mortality represents an unavoidable stage for high-mortality countries transitioning to lower mortality. The "infectious to non-infectious disease ratio" declined significantly only in the high-mortality group, with the high positive correlation between IMR and this ratio indicating that infectious disease mortality reduction exceeded non-infectious disease reduction in high-mortality groups, while these rates declined synchronously in moderate- and low-mortality groups. This suggests prevention priorities should differ across mortality groups.

Global high-, moderate-, and low-mortality groups showed stepwise declines in both IMR and average reduction magnitude, with IMR reduction following a fast-to-slow process roughly characterized as rapid decline, slow decline, and low-level plateau. The stepwise decline in the "infectious to non-infectious disease ratio" indicates differential cause-of-death composition across development stages, suggesting that prevention strategies should be adjusted timely according to development stage. Global IMR shows marked regional variation: Africa highest, Asia second, Europe lowest, and Oceania, South America, and North America intermediate, with Asia gradually approaching intermediate levels. This indicates Africa and Asia should be priority regions for future prevention efforts.

Global per capita GDP growth showed weak negative correlation with IMR reduction, with Africa showing the weakest correlation. North America and 2013 Europe showed weak negative correlations, while other regions showed moderate negative correlations, suggesting that the economic growth-IMR relationship may not be constant and may transition from non-correlation at some point. Identifying this transition point could help governments proactively increase health investment. While previous U5MR analyses recommended increased health investment by mortality group, Tanzania' s increased government health expenditure failed to affect IMR, possibly due to low economic levels, public health expenditure, and service capacity. This suggests limitations to the notion that increased investment automatically reduces mortality. When child deaths result from diseases temporarily unsolvable by medical science, IMR may plateau despite investment. Although health investment currently correlates negatively with IMR, this relationship may eventually transition to non-correlation. More important than investment quantity is aligning investment magnitude with utilization efficiency; inefficient investment cannot maximize mortality reduction effectiveness. Therefore, IMR reduction requires comprehensive, holistic, systematic analysis beyond *World Health Statistics 2015* data to identify key driving factors.

Overall, IMR patterns closely resemble contemporary U5MR patterns, primarily because IMR constitutes a large U5MR proportion and 1–4-year-old mortality has minimal U5MR impact—a influence that will further diminish over time. IMR will increasingly dominate U5MR patterns, making IMR prevention particularly important and urgent.

5.3 Systematic and Precise Prevention and Control Strategies for IMR Reduction

(1) Systematic Prevention Strategy

Given global socioeconomic imbalances, IMR system complexity, and regional IMR disparities, and facing the reality of unachieved child mortality MDGs, governments should actively develop systematic IMR prevention strategies. Efforts should focus on building a new global order, maintaining world peace, developing sustainable prosperous economies, establishing fair social systems, controlling population growth, protecting ecological environments, strengthening agricultural production, ensuring food supply, increasing household income, universalizing compulsory education, transforming customs, promoting healthy behaviors, increasing government health investment, accelerating workforce development, and constructing a three-tier IMR prevention mechanism to extend economic development benefits to child health.

(2) Precise Prevention Strategy

The Human Genome Project advanced genomics to precision medicine. The U.S. implemented a Precision Medicine Initiative, and China included it as a major "13th Five-Year" health security research priority. Precision medicine is driven primarily by DNA sequencing and genomic technologies. Under new medical science guidance, applying these technologies to IMR prevention may yield 事半功倍 (doubled results with half the effort) effects. Non-infectious infant deaths mainly include preterm birth, birth asphyxia, and congenital anomalies. Do preterm and asphyxiated infants carry susceptible genetic information? What genetic variations exist in infants with congenital anomalies? Do infectious disease infants have genetic changes increasing susceptibility? Precision medicine can detect and assess these risks. Implementing precise prevention requires: first, launching a live-born infant genome project with shared databases; second, analyzing genetic factors in infant deaths and assessing high-risk genetic information; third, developing intervention standards and supporting measures for premarital, preconception, prenatal diagnosis, and newborn screening.

(3) Similarities and Differences Between Systematic and Precise Prevention

First, targets differ: systematic prevention addresses external IMR system factors, while precise prevention addresses internal factors. Second, methods differ: systematic prevention focuses on policy development and implementation, while precise prevention emphasizes new technology application. Third, scope differs: systematic prevention operates at macro global levels, while precise prevention operates at micro levels. Fourth, implementing bodies differ: systematic prevention requires multi-sectoral government collaboration, while precise prevention centers on health professionals. However, both share highly consistent goals, and precise prevention requires systematic prevention support to function, needing substantial funding and policy backing from systematic prevention frameworks.

6 Conclusion

Among 194 WHO member states, 40 (20.62%) achieved the IMR MDG while 154 (79.38%) failed, indicating that reducing global IMR remains a formidable task. Global IMR generally declined, with significant reductions across six continents, increasing low-IMR countries and decreasing high-IMR countries. Global IMR reduction follows a high-moderate-low stepwise pattern, with different prevention priorities across mortality groups. Global IMR shows marked regional variation: Africa highest, Asia second, Oceania/South America/North America intermediate, with Asia approaching intermediate levels—making Africa and Asia priority regions. As U5MR declines, IMR proportion in U5MR gradually increases, making active IMR prevention meaningful for global U5MR reduction. IMR influencing factors form a complex multi-domain system, warranting systematic and precise prevention strategies.

7 Limitations and Future Work

This study has limitations due to restricted global IMR data collection. While proposing a holistic IMR complex system concept in the literature review, we only described related content without systematically evaluating different components' relative impacts on IMR. Future research should investigate key driving factors of infant mortality across different countries and regions. This study presents only a temporary, partial static representation of the complex system; future work should innovate methods for dynamic, holistic, systematic IMR research.

Results show global IMR follows a stepwise decline pattern; deeper investigation of this trajectory may help adjust prevention strategies. Findings also suggest the negative correlation between economic growth and IMR reduction may have transitioned from previous non-correlation; research identifying optimal health investment levels at specific economic growth stages could inform investment decisions. This study proposes systematic and precise prevention approaches, but adjusting strategies and implementing specific measures faces considerable challenges and may not yield immediate results. Future policy research should focus on developing multi-sectoral collaboration mechanisms and funding guarantee systems.

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Note: Figure translations are in progress. See original paper for figures.