ORIGINAL ARTICLE

Beyond neonatal and Under-five Mortality: The Case for Infant Mortality in India

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CITATION
Jain K, Gupt RK, das AK. Beyond neonatal and Under-five Mortality: The Case for Infant Mortality in India. Journal of the Epidemiology Foundation of India. 2025;3(3):315-322.
DOI: https://doi.org/10.56450/JEFI.2025.v3i03.005
ARTICLE CYCLE
Received: 26/09/2025; Accepted: 11/12/2025; Published: 31/12/2025

Abstract
Child mortality has been redefined at global platform with Neonatal and under five mortality rates but ignoring Infant mortality rate which measures child survival and reflective of biological, social, economic and environmental conditions in which children live. In the absence of, however, any milestone to achieve, efforts towards controlling IMR can shift to lower priority order having serious repercussions for child health. This paper arguing for the importance of IMR undertook a state level analysis to project the levels for 2025 and 2030 and estimate gender and place of residence-based differentials. The analysis is based on the last two rounds of Sample Registration System, 2019 and 2020. For state level analysis, trajectory of change in IMR across gender and place of residence is described using Annual Average Rate of Reduction (AARR) based on log-linear regression approach and for projection, constant AARR based on 2016-20 level is assumed. The results reveal the rural-urban divide, but what is critical is the differing experience of rural and urban parts of the same state. About gender differentials, females have lesser IMR, but this difference could have been widened. Eastern region and Chhattisgarh in particular needs targeted attention to bring down the levels of IMR.

Keywords
Gender, Rural, Urban, Projection, Annual Average rate of reduction, States

Introduction
In the world of transitions, particularly demographic and epidemiological, global players are making concentrated efforts to ensure sustainable and healthy living. In this process, the United Nations initiated Millennium Development Goals (MDGs) in the year 2000 with eight goals to be achieved by 2015. While these targets were sparsely achieved, they did generate momentum and to sustain this momentum for finishing the unfinished agenda along with newer challenges, making 2015 estimates as baseline, the Sustainable Development goals (SDGs) were constituted.

Child mortality owing to its well stated importance and implications ought to have a place in MDGs; however, considering the limited success countries achieved in

preventing child mortality, SDGs reinstated it as target 3.2: to end the preventable deaths of newborns and children under five years of age by 2030. With adverse impact on the mortality scenario of a nation, it has immediate as well as far reaching implications intervening with population structure. Consequently, a substantial amount of research has gone into understanding its causes and decomposing existing inequalities across regions and socioeconomic groups (Arokiasamy et al., 2013; Prakash and Jain, 2016). Indeed, much of the research has documented a substantial decline in preventable death: the worldwide under-five mortality rate has dropped by 60%, from 93 deaths (12.6 million) per 1000 live births in 1990 to 37 deaths (5.0 million) per 1000 live births in 2020 (Perin et al., 2022). These figures while worth appreciating are not at the warranted pace and could become increasingly concentrated in subnational areas and hotspots (Burke, Heft-Neal & Bendavid, 2016). Evidently, sub-Saharan Africa with highest mortality rates in the world at 74 deaths per 1000 live births have 14 times higher than the risk for children in Europe and North America (WHO, 2020). With India, the situation is more complex. Being identified as a country that had the highest number of under-five deaths, it could not achieve the MDG target of bringing under-five mortality (U5MR) to two thirds of its level from 1990 in 2015 i.e. from 125 to 42 (GoI, 2016). Similarly, for Infant mortality and neonatal mortality (NNMR), the rates did come down but could not achieve the targets i.e. IMR stood at 38 as opposed to the target of 27 and NNMR came down from 57 in 1990 to 28 in 2015 as opposed to target of 16; thereby continued to be the home to the highest number of child deaths (Bora & Saikia, 2018). Needless to mention, diversities in the country do get reflected in the distribution of health and Liu et al., (2019) have documented rising enormous absolute and subnational disparities. According to NFHS-5, the range of U5MR varies from as high as 60 per 1000 live births in Uttar Pradesh to five in Kerala. These disparities not being confined to U5MR are also evident in various other child health indicators such as IMR where Uttar Pradesh has the highest IMR of 64 per 1000 compared to Kerala with six.

The potential role the most populous country can play in controlling preventable deaths is not difficult to visualize. With the gap in the actual rate of decline versus the warranted mandates for a revisit to the efforts; more so considering the role of population structure, health infrastructure and development in impacting the mortality picture. Moreover, diversities within the country are so huge that its various states can have their own trajectory of mortality scenario and so policy implications. Hence, a study assessing the pattern of child mortality for India and its states appears essential to predict if the country can achieve the concerned SDG. In addition to the need for a disaggregated scenario, the role of biological and genetic factors in determining the survival ability of a new-born cannot be overlooked. The mortality of children under age five years can while be calculated independently, is also summative of different mortality rates including IMR and NNMR. These rates compared to U5MR are more likely to capture the impact of biological and genetic factors and more so in case of NNMR. Indeed, declining levels of child mortality can be the result of declining IMR and NNMR; however, the direction and pace of their contribution need not to be aligned. If child mortality is concentrated within the first month of birth; role of biological and genetic factors seems important but if new-borns could by and large survive the first month but not the subsequent months until their first birthday, the role of health care infrastructure looks imperative. Therefore, to have effective policy interventions it is important to target the areas where problem is severe to have a priority order. This mandates a deeper analysis of child mortality and its components.

With this background, the study aims:

- To undertake disaggregated analysis of IMR as it does not appear in any of the SDGs targets.
- To undertake a trend analysis to uncover the states which are performing below the national average considering all India levels as the benchmark in the absence of any recent national target

Material & Methods

The data for investigating IMR at the national and state levels, is compiled from the ~~last~~ latest multiple rounds of Sample Registration System (SRS) reports (SRS,2011 to SRS, 2020). The information about IMR is available by sex (male and female), and place of residence (Urban and Rural).

For state-level analysis, the trajectory of change in IMR according to gender (male and female) and place of residence (Rural and Urban) from 2011 to 2020 is described using the Annual Average Rate of Reduction (AARR). The AARR is the average relative percent decrease per year in prevalence or rate estimated using the log-linear regression approach. A positive sign indicates a reduction or a declining trend in the concerned variable and a negative sign indicates an increase or an upward trend. The following model is used to calculate the AARR.

If the prevalence of infant mortality rate in a baseline year t_0 is Y_0 , then

$Y_{ti} = Y_0*(1-b\%)\ (t_i - t_0)$ (I)

Taking log on both sides of equation I,

$\ln (Y_{ti}) = \ln(Y_0) + (t_i-t_0) *\ln (1-b\%)$

$= \ln(Y_0) + t_i*\ln(1-b\%) – t_0*\ln(1-b\%)$

$= \beta*t_i + C_0$ (II)

where, $\beta = \ln(1-b\%)$

$C_0 = \ln(Y_0) – t_0*\ln(1+b\%)$, a constant

Hence,

$AARR = 1 - \exp(\beta)$ (III)

$SE(AARR) = \exp(\beta)\ SE\ (\beta)$. (IV)

The standard error (SE) in equation IV is calculated using delta method proposed by WHO-UNICEF Technical Expert Advisory Group on Nutrition Monitoring (TEAM), 2017)

2.4. Statistical analysis

The estimated AARR is done for two consecutive periods, 2011-15, and 2016-20 separately for each state. The starting year of the second period is selected as 2016 as most of the interventions were started in 2013-14 and we assumed one-year time for rolling out the interventions, and it divides the 10 years into equal two five-year windows, an assumption of the model used here.

The projection of state-level child mortality rates in 2025 and 2030 is done assuming a constant AARR of the 2016-20 level.

Finally, the change in the AARR between the period of 2011-15 and 2016-20 is computed as Absolute change= AARR (2016-20) – AARR (2010-15), which means a negative sign indicates a decline in the rate between the two periods. On the other hand, the relative change is computed as relative change=AARR (2016-20) / AARR (2010-15), which means a value <1 indicates a decline in the rate between two periods.

Results

Pattern of IMR by place of residence and gender:

This section presents the results for IMR which is investigated for overall levels and by place of residence and gender as well as projecting it for the same characteristics.

Figure 1 to 4 presents the results for the trend analysis of IMR undertaken at the overall level, by place of residence and gender (figure 1) followed by regional analysis (figure 2 to 4). As evident in figure 1, there is a consistent decline in the level of IMR at the national level from 44 to 28 per 1000 live births during 2011 to 2020, But this decline also reveals a much better position of urban areas compared to rural India. In rural areas, while the IMR in year 2011 was 48 per 1000 live births which decreased 31 per 1000 live births in 2020; the number for the urban areas were 29 and 19 per 1000 live birth respectively. Further about gender differentials, females were having higher infant mortality (43) compared to male (46) in year 2011 but with continuous efforts on reducing the gender differentials, the gender gap did close down in 2020 with IMR at 28 per 1000 live births for both male and female.

In the eastern part West Bengal emerged as the state with lowest level of IMR which dropped from 32 per 1000 live births in 2012 to 19 per 1000 live births in 2020 and Assam recorded the highest IMR in 2012 at 55 per 1000 live births but saw a substantial decline to 36 per 1000 in 2020. The other states fluctuated in terms of IMR between the numbers registered for West Bengal and Assam. Bihar exhibiting a positive trend, registered a decline in IMR from 43 per 1000 in 2012 to 27 per 1000 in 2020. Similarly, Chhattisgarh, which had an IMR of 47 per 1000

in 2012, witnessed an IMR of 38 per 1000 in 2020 reflecting a consistent progress in controlling the unwanted mortality. Jharkhand demonstrated a consistent decline, reducing its IMR from 38 per 1000 live birth in 2012 to 25 per 1000 live births in 2020. Odisha had an IMR of 53 per 1000 live births in 2012, but achieved a substantial reduction to 36 per 1000 live births in 2020 sharing the same number as of Assam.

Northern region states indicate decline trend of IMR over the years, where Delhi had a low IMR, reducing from 25 per 1000 live birth in 2012 to 12 per 1000 live births in 2020. Gujarat saw a steady decline from 38 per 1000 live birth in year 2012 to 23 per 1000 live birth in 2020. Haryana improved from 42 per 1000 live birth in 2012 to 28 per 1000 live birth in 2020. Himachal Pradesh had the lowest IMR in this region, declining from 36 per 1000 live birth 2012 to 17 per 1000 live birth in 2020. Madhya Pradesh had the highest IMR, decreasing from 56 per 1000 live birth in 2012 to 43 per 1000 live birth in 2020 but still remained the worst in the northern region. Punjab improved from 28 per 1000 live birth in 2012 to 18 per 1000 live birth in 2020. Rajasthan saw a decline from 49 per 1000 live birth in 2012 to 32 per 1000 live birth in 2020. Uttar Pradesh had a very high IMR but showed progress, decreasing from 53 per 1000 live birth in 2012 to 38 per 1000 live birth in 2020. Uttarakhand showed a gradual reduction from 34 per 1000 live birth in 2012 to 24 per 1000 live birth in 2020. (figure-3).

Considering the southern region all southern states have shown a consistent decline in IMR. Kerala not only outperforms rest of the states in the southern area but also emerged as the state with the lowest level of IMR in the year 2020 at all India level i.e. Six (figure 4) which decline from 12 per 1000 live births in 2011. Kerala has the lowest IMR six per 1000 live birth in year 2020, Andhra Pradesh started with highest IMR but improved significantly from 43 per 1000 live births in 2011 to 24 per 1000 live births in 2020, Karnataka decreased from 35 per 1000 live births in 2011 to 19 per 1000 live births in 2020, Maharashtra saw a steady decline from 35 per 1000 live births in 2011 to 16 per 1000 live births, and Tamil Nadu have also made steady progress from 22 per 1000 live births to 13 per 1000 live births in 2020. Southern states overall have a lower IMR compared to northern and eastern states.

Projected levels of IMR, 2025 and 2030

The map illustrates the state-level variation in Infant Mortality Rate (IMR) between 2025 and 2030. It highlights that among the 22 major states of India, six states belonging to the Empowered Action Group—namely Assam, Chhattisgarh, Madhya Pradesh, Odisha, Uttar Pradesh, and Jharkhand—are projected to continue having high IMRs in 2030.

Annual Average Rate of Reduction and Projection

1. India and States

The Annual Average Rate of Reduction of IMR for India and major states is shown in Table 1 (and table A1). Overall, India has experienced a decline in AARR between 2011-15 and 2016-20, a relative change of 0.3 (CI: 19.5 – 0.55). Analyzing the state level variations, reveals that in the case of South India, Andhra Pradesh has shown significant improvement in AARR from 3.4 to 9.3 between 2011-15 and 2016-20. Similarly, Tamil Nadu has also witnessed an increase from 3.4 to 5.8 while Maharashtra has experienced a slight decrease from 4.7 to 4.4 between two time-periods. The experience of Kerala is much different than the rest of the states as the value of AARR in the first time-period stands at zero but increased to 14.2 for the time period of 2016-20; consequently, generating the maximum absolute advantage. The reason for such a scenario can be traced from Figure 4 where Kerala has maintained the same level of IMR in the first period. In terms of relative change, out of six states, Andhra Pradesh showed significant improvement at -1.74 (LB: -1.84, UB: -1.59) with two states registering no relative change. In ten of the north India states, Uttarakhand depicted a higher absolute change of 8.9 (CI: 9.6– 8.1) and a negative relative change in AARR between the last two periods, -6.357 (CI: -8.0 - -1.98) with least change in Delhi (absolute: -0.7 and relative: -0.07). Madhya Pradesh has also shown a reduction in AARR from 4 to 2 between two decades, with a relative change of 0.500 (CI: 1.00-0.07) indicating a decrease in reduction rate. It is also the state which has

consistently higher IMR. Considering the six states of Eastern region, Bihar showed a higher absolute increase of 7.1 (CI: 7.4-6.9) and a negative relative change in AARR between the last two periods, -5.92 (CI: -14.80 to -3.83) suggesting a significant shift. The change in AARR does reflect the direction in which the states will be moving with regard to IMR and this led to the projection for the year 2030. India as a whole is projected to have an IMR of 14.8 in the year 2030 with variations at state level from -2.5 for Kerala to 38 for Chhattisgarh. Seven states have projected IMR higher than the national average which includes Uttar Pradesh, Madhya Pradesh, Haryana and all Eastern states except West Bengal and Bihar.

2. Rural-Urban differentials, India and States

The study calculated Annual Average Rate of Reduction of IMR for rural India which increased from 3.8 to 4.8, showing a relative change of -0.26 (CI -0.54 – 0.03) as depicted in table-2 (and table A2). With regard to state level variations for rural India, amongst five of the South Indian states, Kerala depicted the highest absolute change of 19.5 (CI: 12.5 – 26.6) and a positive relative change in AARR between the last two periods, 27.86 (CI: 4.17 to -17.73). Maharashtra and Karnataka did not depict much change while Tamil Nadu and Telangana registered the absolute change in AARR around 4 and Andhra Pradesh stood at 6.3. Moving to northern states, out of 10 states, four depicted positive absolute change in AARR which includes Uttarakhand, Rajasthan, Himachal Pradesh and Gujarat. Considering the eastern states, Bihar registered absolute change of 7.5 (CI: 7.8 – 7.1) and a negative relative change in AARR between the last two periods at -4.691 (CI: -15.60 to -2.63). Out of these six states, Chhattisgarh emerged as the state with a negative absolute change of -3 (CI: -3.7 to -2.2). Essentially the state has registered substantial decline in the first time period (2011-15) but could not maintain the same pace of decline. In terms of projected IMR, rural India is expected to touch a figure of 10.4 with 11 states responsible for pulling the average on the higher side. Chhattisgarh is projected to be the worst performing state with IMR of 39.2 in the year 2030.

The study has further calculated the AARR and projections for IMR across urban India. The AARR for overall urban India registered an increase from 3.3 to 5.1, with a relative change of -0.55 (-0.58 to -0.53) as evident in table-3 (and table A3). Moving into the state level, Analysing the regional variations, in northern urban India, Uttarakhand depicted the highest absolute change of 33.5 (CI: 43.0 to 24.0) and a positive relative change in AARR between the last two periods, 1.18 (CI: 1.05 to 1.51) followed by Kerala with absolute change of 11.8 (CI: -7.9 – 31.6) and relative change 3.69 (CI -1.49 – 28.73) and Bihar registering absolute change of 10.8 (CI 11.9 – 9.6) with relative change 1.66 (CI 1.06-5.33). With regard to projected values in 2030, urban India stands at 5.9 with 13 states pulling the average on the higher side. The worst performing state will be Chhattisgarh with the projected value of 32.9 followed by Jharkhand at 20.2. Overall, the eastern region of the country needs more of the targeted attention to bring down the levels of IMR.

2. Gender differentials, India and States

India is a nation which is known for its diversities; while a few of them such as regional adds to the country; the others put the nation in difficult space by giving rise to inequalities. One such widely acknowledged inequalities is gender which is deeply rooted in the patriarchal system; however, when it comes to the indicators that carry the impact of biological factors; gender differentials tend to weaken. One such indicator is the variable understudy as IMR is a combination of biological and social factors with females being biologically stronger but owing to patriarchy weaker in social structure. As evident in table 4 and 5, the projected value of IMR for males is higher than females in the year 2030 i.e. 8.2 and 5.8 respectively at all India levels. In terms of absolute change, the AARR for males stands at -1.8 while for females it is +1.

Analyzing the state level variations in terms of AARR and projected IMR for males (table 4), while the state for Kerala depicted the minimum (zero) absolute change but its essentially due to constant levels of IMR

amongst boys in the first time-period. In terms of relative change, Uttarakhand, Andhra Pradesh followed by Tamil Nadu, have higher negative relative change with values at -5.80; -4.47 and -4 respectively. With regard to projected values, the state of Chhattisgarh, Punjab and Haryana will be the worst performing states having higher than the national level average with values of 28.4, 22.9 and 20 respectively in the year 2030.

Analyzing the state level variations in terms of AARR and projected IMR for females (table 5 and table A5), the results for Kerala depicted maximum absolute change that of males in terms of absolute change. Himachal Pradesh 15 (CI: 12.8 to 17.1) followed by Bihar 10.6 (CI: 9.5 to 11.5); Uttarakhand 9.9 (CI: 6.4 to 13.4) and Telangana 8.6 (CI: 5.9 to 11.2) registered higher absolute change.. In terms of relative change while Bihar has the highest positive relative change 15 (3.80 to 9.58); the contrary picture is depicted by states of Uttarakhand, Himachal Pradesh, West Bengal and Rajasthan with values at -16.50 (CI: 3.37 to -4.47); -5.17 (CI: -6.40 to -4.38), -2.67 (4.53 to 1.74); and -2.40 (CI: -6.75 to -1.42) respectively. About projection, Chhattisgarh will be having the worst IMR in the year 2030 at the value of 50.4 followed by Punjab at 21.8, Odisha at 19.1.

Discussion

There is no second thought about the decline India has achieved in controlling its avoidable deaths due to IMR. It however raises two critical questions, whether this decline is consistent across all the indicators i.e. by place of residence and gender and if all the states are following the same trajectory of decline. These questions are essential to be answered considering the variable under study. Any death which is untimely must be avoided; moreover, in the context of children and that too concentrated underage one is reflective of failure of health machinery as well as the indicator of position of women in the society. The health status of infants is dependent on the immediate surrounding environment as well as the care mother has received during her pregnancy. It is in this context the study examined decline in IMR across states, place of residence and gender along with the projections for the targeted year 2030.

There is a clear downward trend in IMR registered for total, place of residence and gender. The state level variations are also reflecting the same. However, the pattern of decline is not consistent: as evident in the results, the urban areas are standing apart from rest of the classification; in fact, the highest recorded IMR for urban areas has not been matched by other classifications except by females and that too in the year 2020. It is the rural areas and being a female child is putting the infant under major risk of death. These are the findings which reflect the continued weaker state of areas which were always in need of attention. Despite focussing on women empowerment, son preference is still evident to an extent that female life is not considered at par with that of male.

Further with regard to state level variation, a clear north-south divide is visible with southern states outperforming northern states. The state which has the highest level of IMR across India in the year 2020 is Madhya Pradesh followed by Chhattisgarh and Uttar Pradesh. It is the state of Haryana that has made considerable progress. In terms of AAR, Kerala has registered maximum absolute change but this is not the movement from high to low IMR; rather, in the first time-period from 2011 to 15, it has consistently maintained the IMR at 12. Similarly, Chhattisgarh stands at the opposite side with negative absolute change owing to slower pace of mortality decline in the second time period which indicates weaker position of the state. The other states to register the higher absolute change included Telangana (9.6), Uttarakhand (8.9), Bihar (7.1); and Andhra Pradesh (5.9). With regard to relative change, except for Uttarakhand there is not much change, reflecting a sustained level of IMR; which is not indicative of good sign until IMR values are at an accepted lower level. Consequently, the projected IMR for states of Uttar Pradesh; Madhya Pradesh; Haryana; Odisha; Jharkhand and Chhattisgarh stands at much higher level than all India projected IMR.

The rural-urban divide in terms of various indicators including health infrastructure is

widely evident which would probably be continued in future as it gets evident through projected IMR: the projected IMR for rural and urban India stands at 10.4 and 5.9 respectively. In terms of maximum or least absolute advantage, the states differ in rural and urban scenarios indicating different sets of challenges for them. The policies are probably not working in the same manner across urban and rural parts of the same state. For instance, in the case of Delhi rural, the IMR values largely declined throughout but in the year 2020, it increased touching a figure of 20 while its urban part continued to witness a decline. Out of six states in the East region of India, five states will be having higher projected IMR than all India urban level with substantial difference varying between 32.9 for Chhattisgarh to 6.8 for Assam; but the number reduces to four in the context of rural areas varying between 39.2 for Chhattisgarh to 15.3 for Jharkhand. While the maximum absolute change is registered for Kerala as was in the case of total, Andhra Pradesh, Uttarkhand and Haryana are the other three states reflecting a declining levels of IMR in rural areas. Few states such as Delhi, Chhattisgarh have registered a negative AAR which means in the second period the IMR in rural areas has not declined as it declined in the first period. With regard to urban India, the absolute change in AARR, unlike for total and rural indicator, is registered for Uttarakhand, Bihar and Jammu and Kashmir with all three states registering considerable decline in the second period after consistently maintaining the same level of IMR.

Conclusion

In the world of growing attention towards the quality of life, when indicators such as HALE, DALY (Wang et al., 2020) are increasingly gaining the focus; the importance of child health need not be explicitly stated. It is one such area which had been under focus and the efforts did yield the result; however, decomposing the indicators of child mortality and dropping IMR from the targets of SDGs has put the latter under less focus. Indeed, Neonatal mortality and child mortality are there in the list; but the former captures the impact of biological factors more strongly while the latter reflects the societal structure and health machinery. It is the IMR that captures the impact of both the factors comparatively in a better fashion. Moreover, until a consistent decline is observed across all the states and by all indicators, the success is not yet achieved. The study therefore attempted to investigate the IMR in terms of its decline across states and by place of residence and gender as well as projecting its level for 2030, the year marking the end of SDGs. The results did reveal the rural-urban divide but what is more critical is the differing experience of rural and urban parts of the same state. Further, with regard to gender differentials while females have lesser IMR but this difference could have been widened if women are considered at par in the patriarchal country. Being specific to the regions, the eastern region of the country needs more of the targeted attention to bring down the levels of IMR and with regard to states, Chhattisgarh is in dire need of dedicated attention. In addition, health infrastructure should also be strengthened to reduce the projected levels of IMR for both males and females.

IMR has been ignored in the SDGs, but this should not be interpreted in terms of reducing the efforts to reduce IMR levels. The study reveals a higher level of projected IMR which warrants for efforts and policy interventions.

Recommendation

The study recommends for targeted intervention in rural areas particularly when urban areas of the same state are showing improvement. Similarly with reference to gender differentials, the biological strength of females should be strengthened further. Overall, Chhattisgarh is in most adverse form with regard to IMR.

Limitation of the Study

Since this study is based on secondary sources of data, it remained silent on providing reasons for the results which mandate for qualitative insights. Also, while the data is not very recent, however we believe the direction of results will not vary much. The latest data as per the availability can be used to support the existing study as future course of research.

Relevance of the Study

The study is very relevant particularly when the world has gradually drifted away from IMR. It plays a vital role in reinstating its importance along with highlighting those areas which need intervention. It cannot be substituted with any other indicator of Child mortality; efforts dedicated towards IMR need to re-strengthened.

Authors Contribution

All authors have contributed equally.

Financial Support and Sponsorship

Nil

Conflict of Interest

There are no conflicts of interest.

Declaration Of Generative AI And AI Assisted Technologies In The Writing Process

The authors have used for plagiriam (Author declaration required i.e. During the preparation of this work, the authors used Grammarly software in order to check for AI and plagiarism. After using this tool/service, the author (s) reviewed and edited the content as needed and take (s) full responsibility for the content of the publication).

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