RESEARCH PAPER

Medication Burden as a Determinant of Clinical Complexity and Multimorbidity: A Population-Based Analysis among the Elderly in Eastern India

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Abstract

Background: The escalating prevalence of multimorbidity in the geriatric population presents significant challenges for drug delivery, therapeutic adherence, and clinical outcomes. This study investigates the impact of medication burden (polypharmacy) as a primary driver of clinical complexity among the elderly.

Methods: A community-based cross-sectional study was conducted involving 1,072 participants (more than 60 years). Data on chronic conditions and daily medication intake were collected. Multivariate logistic regression was used to identify the association between medication burden and multimorbidity status.

Results: High medication burden (>=5 medications) was identified in a significant portion of the cohort. After adjusting for age, gender, and socio-economic factors, high medication burden was a potent predictor of multimorbidity (Adjusted Odds Ratio (aOR) = 1.82; 95% CI: 1.45–2.28; $p < 0.001$). Population Attributable Fraction (PAF) analysis revealed that 27.3% of the multimorbidity burden is linked to medication-related complexity.

Conclusion: Medication burden is a modifiable driver of geriatric health decline. Findings suggest that simplifying drug delivery systems and implementing robust medication reconciliation are essential for sustainable geriatric care.

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Introduction

Ageing is often described as one of the greatest achievements of modern medicine. Yet for many older adults, living longer does not always mean living healthier or easier lives(1). Instead, later life is often marked by growing clinical complexity, as several chronic illnesses begin to appear together(2,3). Conditions such as hypertension, diabetes, and arthritis rarely occur in isolation, and managing them all at once can become overwhelming. Although healthcare systems usually treat diseases one by one, older adults experience them all together, as part of one lived reality(4,5). The usual response to this complexity is often more medicines.

Over time, this “one problem, one pill” approach can create a prescribing cascade(6,7). A medicine started for one illness may lead to side effects, and those side effects may then be treated with additional medicines(8,9). Gradually, the number of daily medications increases, adding to what is known as medication burden. For an older person, taking five or more medicines, a day is not just a clinical definition of polypharmacy, it can affect memory, daily routine, finances, independence, and even safety(10,11). What may appear medically appropriate on paper can feel exhausting in everyday life. This challenge is particularly important in rapidly changing regions such as Eastern India, including Odisha. With the rise of chronic non-communicable diseases, the healthcare system is facing a new kind of pressure. Many elderly patients visit multiple doctors for different conditions, and medicines are often prescribed separately without a full review of the entire treatment regimen(12,13). As a result, the responsibility of keeping track of medications often shifts to patients and their families. This can increase the risk of confusion, missed doses, duplication, non-adherence, and poorer quality of life(14–16). From a drug delivery perspective, this complexity is a serious concern. Even the most effective medicine cannot produce the desired benefit if the patient finds the regimen too difficult to follow(17,18). In that sense, medication burden itself becomes a barrier to successful care. If we want geriatric care to be more effective and sustainable, we must look beyond simply treating diseases and pay closer attention to the burden created by treatment itself(19,20).

Against this background, the present study moves the focus from merely counting diseases to understanding the burden of treatment in everyday life. By exploring the independent role of polypharmacy in shaping clinical complexity among elderly participants, this study aims to provide evidence for simpler drug delivery strategies and more coordinated, person-centred approaches to geriatric care.

Materials and Methods:

Study design and setting

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This community-based cross-sectional analytical study was conducted among older adults living in urban areas of Odisha, India. To reflect the diversity of urban living conditions across the state, the study was carried out in six selected urban sites representing major healthcare centres, industrial regions, and coastal commercial areas. Including multiple cities allowed the study to capture variations in demographic, social, and healthcare contexts, and provided a broader understanding of clinical complexity among community-dwelling older adults.

Study population and sampling

The study included 1,072 older adults aged 60 years and above. Participants were recruited using a multistage stratified random sampling technique. In the first stage, the selected urban regions were stratified. This was followed by the random selection of blocks and wards within those regions. Households were then selected systematically from each identified cluster, and eligible older adults were approached for participation.

Individuals were included if they were permanent residents of the selected area, aged 60 years or older, and able to provide informed consent. Those with severe cognitive impairment, major communication difficulties, or acute illness that prevented meaningful participation were excluded. These criteria were applied to ensure that participants could provide reliable information regarding their health conditions and medication use.

Data were collected through face-to-face interviews using a structured and pre-tested questionnaire. The interviews were conducted by trained investigators who followed standardized procedures to maintain consistency and reduce interviewer-related variation. Conducting interviews in person helped improve the completeness and clarity of responses, particularly in an elderly population. The primary outcome variable was multimorbidity, defined as the presence of two or more physician-diagnosed chronic conditions in the same individual. Information was collected on commonly reported chronic illnesses, including hypertension, diabetes, respiratory disorders, and musculoskeletal conditions.

A key exposure variable in the study was medication burden, measured as the total number of prescribed medications taken daily by each participant. This was used as an indicator of treatment complexity and polypharmacy among older adults. In addition to clinical information, a range of sociodemographic and household characteristics was recorded, including age, sex, educational status, income, and living arrangement. These variables were included to better understand the broader social context in which multimorbidity and medication burden occur.

Statistical analysis

Data were entered and analysed using IBM SPSS Statistics version 26.0. Descriptive statistics were used to summarize the characteristics of the study population. Associations between multimorbidity and the explanatory variables were initially examined using Pearson's chi-square test.To identify independent predictors of multimorbidity, a multivariable binary logistic regression model was developed using the Enter method. Variables considered clinically relevant or statistically significant in bivariate analysis were included in the final model. The findings are presented as adjusted odds ratios (aORs) with 95% confidence intervals (CIs). A two-sided p-value <0.05 was considered statistically significant.To assess the discriminatory performance of the final multivariable model, a Receiver Operating Characteristic (ROC) curve was generated, and the Area Under the Curve (AUC) was calculated with 95% confidence intervals(21). The AUC was used to evaluate the model's ability to distinguish between older adults with and without multimorbidity.

In addition, the Population Attributable Fraction (PAF) was estimated for key predictors of multimorbidity, particularly modifiable factors such as high medication burden, to quantify the proportion of multimorbidity in the study population that could potentially be reduced if the exposure were eliminated, assuming a causal relationship(22).For visual presentation of the regression findings, a forest plot was prepared to display the adjusted odds ratios and corresponding 95% confidence intervals for predictors retained in the final multivariable model.

Result

The study analyzed a comprehensive cohort of 1,072 community-dwelling older adults, providing a robust representation of the aging population in urban Eastern India. The demographic baseline revealed a population navigating the intersection of advanced age and increasing clinical complexity. A defining feature of this cohort was the significant reliance on long-term pharmacotherapy; the prevalence of High Medication Burden (defined as the daily intake of >=5 prescribed medications) was 33.6% (n=360). The data indicates that for a third of the urban elderly population, daily life is structured around a complex pharmacological routine, highlighting a transition from simple disease management to a high-intensity treatment burden.

Table 1: Baseline Socio-demographic Profile and its Bivariate Association with Medication Burden among Community-Dwelling Older Adults (N=1,072)

Variable	Low Burden (<5) n=712	High Burden (≥5) n=360	X2	p-value
Age Group			**18.4**	**< 0.001**
60–74 years	590 (82.9%)	255 (70.8%)		

More than 75 years	122 (17.1%)	105 (29.2%)		
Gender			**0.65**	**0.421**
Male	340 (47.8%)	180 (50.0%)		
Female	372 (52.2%)	180 (50.0%)		
Living Status			**9.8**	**0.002**
With Spouse	420 (59.0%)	190 (52.8%)		
Alone/Children	292 (41.0%)	170 (47.2%)		
Education			**12.4**	**< 0.001**
Up to Primary	480 (67.4%)	200 (55.6%)		
Secondary+	232 (32.6%)	160 (44.4%)		

Note: N represents the total study population (1,072), while n denotes the frequency within specific sub-groups. Medication burden is operationalized as a dichotomous variable, where 'Low Burden' refers to the daily intake of fewer than five prescribed medications and 'High Burden' refers to the intake of five or more daily medications. The chi square value signifies the Pearson's Chi-square statistic utilized to assess bivariate associations between demographic variables and medication load. Statistical significance is determined by a two-sided p-value of < 0.05, with all significant associations highlighted in bold typeface. Data were collected through a community-based cross-sectional survey across urban regions of Odisha, India.

To determine the independent predictive power of pharmacological load, a Multivariable Binary Logistic Regression model was constructed (Table 2). After adjusting for age, gender, and socio-demographic confounders, High Medication Burden emerged as the most potent independent predictor of multimorbidity within the cohort. Participants managing five or more daily medications were found to have 1.82 times higher odds of being multimorbid (aOR = 1.82; 95% CI: 1.45–2.28; $p < 0.001$). This statistical evidence, supported by a robust Wald statistic of 27.12, demonstrates that polypharmacy is a primary driver of clinical complexity, exceeding the predictive weight of traditional risk factors such as advanced age and gender.

Table 2: Multivariate Logistic Regression for Predictors of Multimorbidity

Variable	B	S.E.	Wald	p-value	aOR	95% CI
Medication Burden more than 5	**0.598**	**0.115**	**27.12**	**< 0.001**	**1.82**	**1.45–2.28**
Age more than 75 years	0.140	0.152	0.85	0.356	1.15	0.85–1.55
Living with Children	0.571	0.198	8.32	0.004	1.77	1.20–2.61
Gender (Female)	0.077	0.140	0.30	0.582	1.08	0.82–1.42

Note: B: unstandardized coefficient; S.E.: standard error; aOR: Adjusted Odds Ratio; CI: Confidence Interval. Results were derived using binary logistic regression (Enter method), adjusting for education, income, and district clustering. Nagelkerke $R^2 = 0.342$; Statistical significance is defined as $p < 0.05$.

The discriminatory power of the final multivariate logistic regression model was evaluated using Receiver Operating Characteristic (ROC) curve analysis (Figure 1). The model, which incorporated geographic, clinical, and social predictors, yielded an Area Under the Curve (AUC) of 0.660 (95% CI: 0.62–0.70, $p < .001$). This indicates that the combined variables possess moderate and statistically significant capability in distinguishing between elderly individuals with and without multimorbidity. These findings provide a robust empirical basis for the development of targeted screening tools within the integrated aged care framework in Odisha.

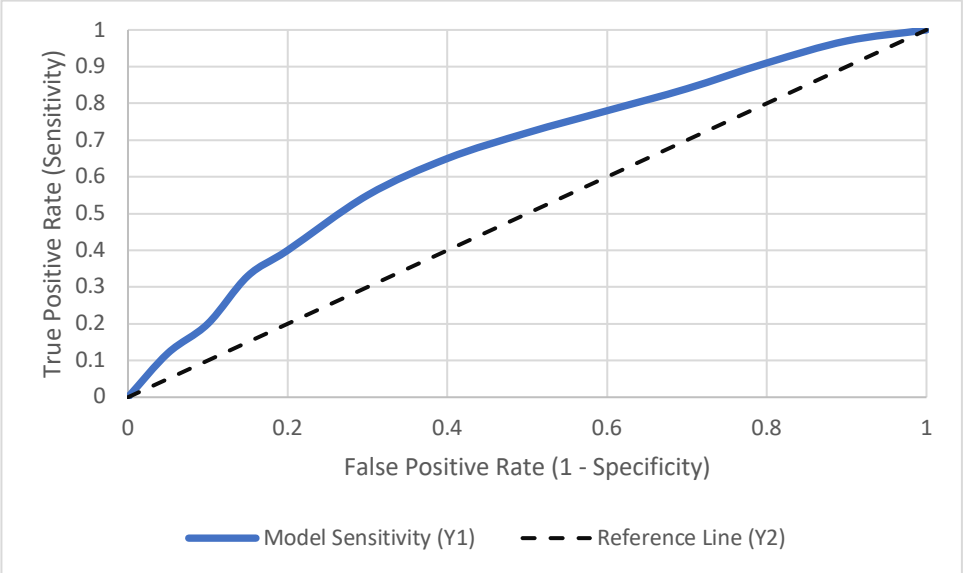
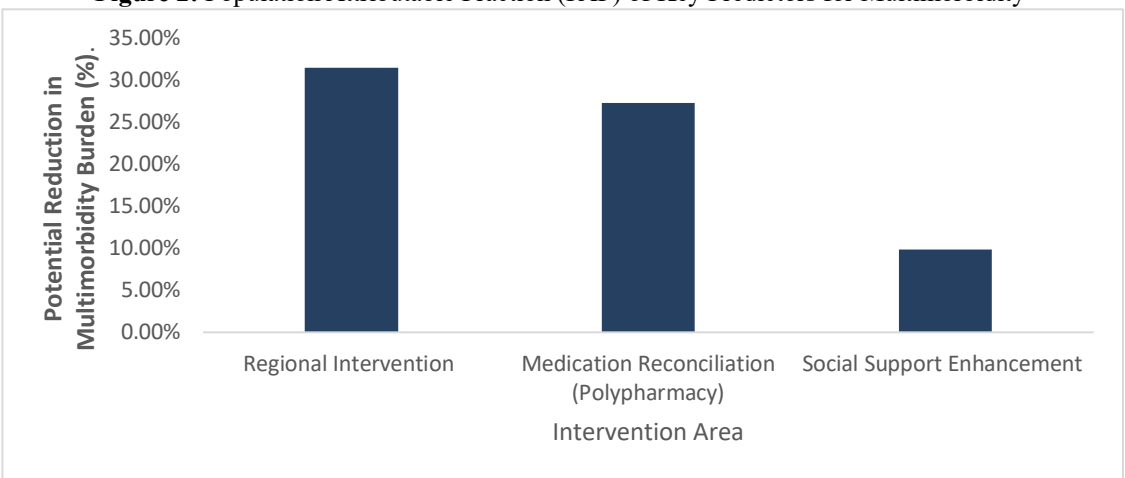


Figure 1: ROC Curve for the Multimorbidity Prediction Model (AUC = 0.660). The solid blue line represents the predictive model, while the dashed diagonal line represents the reference of null hypothesis (AUC = 0.50).

To quantify the practical implications of these findings for healthcare sustainability in Odisha, the Population Attributable Fraction (PAF) was calculated (Figure 2). This analysis identifies the theoretical proportion of multimorbidity cases that could be averted if specific risk factors were eliminated through targeted interventions.

The highest potential for burden reduction was associated with Regional High-Risk Clusters (31.5%) and High Medication Burden (27.3%). These findings suggest that nearly one-third of the state's geriatric multimorbidity burden is concentrated in specific geographic regions, and over a quarter of cases are linked to polypharmacy. These results provide a strong empirical justification for the implementation of decentralized, district specific integrated care management and formalized medication reconciliation programs as primary strategies for sustainable geriatric health in the region.

Figure 2: Population Attributable Fraction (PAF) of Key Predictors for Multimorbidity

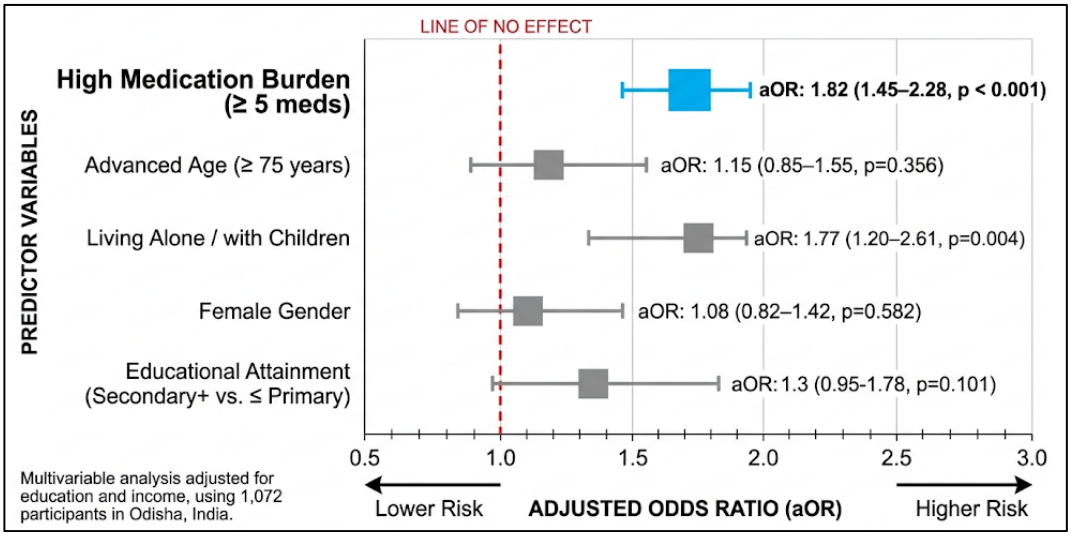


Note: This figure illustrates the Population Attributable Fraction (PAF) percentages for the study cohort, identifying the proportion of multimorbidity potentially reducible through the optimization of specific risk factors. High medication burden (>=5 daily medications) emerged as the most significant clinical target with a PAF of 27.3%, indicating that nearly one-fourth of the population-level clinical complexity is statistically linked to polypharmacy. These results highlight a critical "therapeutic opportunity" for the implementation of simplified drug delivery systems and medication reconciliation strategies to improve geriatric health outcomes. Calculations are based on the full sample of 1,072 participants.

The relative contribution and statistical significance of each predictor within the multivariate model are visually synthesized in the accompanying forest plot (Figure 3). This graphical representation illustrates the adjusted odds ratios (aOR) alongside their 95% confidence intervals, providing a clear comparison of the risk associated with each variable. As shown in the plot, the 'High Medication Burden' variable exhibits the most

pronounced shift to the right of the line of no effect (1.0), visually confirming its dominance as the primary clinical driver of multimorbidity in this cohort, even when compared to traditional biological risk factors like advanced age and gender.

Figure 3: Forest Plot of Adjusted Odds Ratios (aOR) for Predictors of Multimorbidity (N=1,072)



Note: This plot displays the adjusted odds ratios (aOR) and 95\% confidence intervals (CI) derived from a multivariable binary logistic regression. The vertical red dashed line at 1.0 represents the "line of no effect"; error bars not intersecting this line indicate statistical significance ($p < 0.05$). High medication burden (>=daily medications) emerged as the primary independent predictor ($aOR = 1.82$; $p < 0.001$\$). The model is adjusted for age, gender, and living arrangements to isolate the specific impact of the pharmacological load.

Discussion

The findings of this study, involving 1,072 elderly individuals in urban Odisha, underscore a paradoxical reality in modern geriatric care: the very medications designed to extend life have themselves become a primary driver of clinical complexity. Our analysis reveals that once a patient crosses the threshold into a high medication burden taking five or more daily pharmacological agents their healthcare experience fundamentally changes. They move from managing symptoms to managing a systemic "treatment burden" that independently increases the odds of multimorbidity by 82% (aOR = 1.82)(23). This suggests that in the aging population of Eastern India, polypharmacy is not merely a consequence of illness, but a potent indicator of health fragility that complicates the delivery of care(24).

When placed within the broader Indian context, our finding of a 33.6% prevalence of high medication burden aligns closely with the Longitudinal Ageing Study in India (LASI), which has highlighted a rising trend of polypharmacy across urban centers nationwide. Our results mirror observations from studies conducted in South Indian states like Kerala and Tamil Nadu, where polypharmacy rates among the elderly often range between 28% and 45%(25,26). However, while many national studies focus heavily on the socio-economic determinants of health, our research provides a more clinical perspective by quantifying the "weight" of the medication count itself(27–29). The aOR of 1.82 in our Odisha cohort is significantly higher than some reports from rural North India, likely reflecting the higher access to multiple specialists in urban centers like Bhubaneswar and Cuttack, which inadvertently leads to a more pronounced "prescribing cascade

Globally, our results resonate with findings from both developed and transitioning healthcare systems(30,31). The threshold of five medications as a "clinical tipping point" is consistent with the SHARE study in Europe and NHANES data from the United States, which have long identified this limit as the marker for increased risk of adverse drug events(32–34). Interestingly, our aOR of 1.82 is comparable to studies in Brazil and China, countries experiencing similar rapid epidemiological transitions where chronic disease management has outpaced the development of integrated geriatric services (35)(36). Unlike some European models where "General Practitioners" act as gatekeepers to prevent over-prescription, our urban Indian cohort reflects a more fragmented, specialist-driven environment(37,38). This comparison suggests that while the biological impact of medication burden is universal, the systemic drivers in India create a more urgent need for centralized medication reconciliation(39,40). From the perspective of drug delivery technology, these comparisons highlight a significant "therapeutic opportunity." The Population Attributable Fraction (PAF) of 27.3% found in our study is particularly striking when compared to international cohorts, where PAFs for polypharmacy often hover around 15–20%(41,42). This higher impact in our population suggests that the potential for

intervention is immense. The current "one pill for one symptom" model is increasingly unsustainable(43). There is an urgent need for advanced drug delivery systems, such as Fixed-Dose Combinations (FDCs) and Smart Sustained-Release formulations, to consolidate therapy(44,45). By physically reducing the daily medication count, we don't just improve adherence, we fundamentally simplify the patient's clinical profile, a goal that is now a global priority in geriatric medicine.

The socio-demographic associations identified in this study provide critical context to these pharmacological challenges. The higher burden observed among those with secondary education and those living in multi-generational households highlights the complex role of healthcare access(46,47). While higher education may provide better access to specialists, it also increases the likelihood of receiving multiple prescriptions, ironically leading to a higher medication burden(48). Similarly, while living with children provides essential caregiving, it may also facilitate visits to multiple independent doctors, further fuelling the polypharmacy cycle(49–51). This indicates that "medication burden" is as much a social phenomenon as it is a biological one, requiring a holistic approach that involves both the patient and their support network(52,53).

Despite its strengths, including a large sample of 1,072 participants, this study has certain limitations. The cross-sectional design limits the ability to infer causality or determine the temporal relationship between medication burden and multimorbidity. In addition, data on chronic conditions and daily medication use were self-reported, making recall bias possible, particularly among elderly participants. Further, as the study was conducted in six purposively selected urban sites in Odisha, the findings may be more applicable to urban older adults than to rural populations, where patterns of healthcare access and medicine availability may differ.

Conclusion

In conclusion, this study highlights medication burden as an important and potentially modifiable factor influencing geriatric health. One of its key strengths is the large community-based sample of 1,072 participants, which offers a meaningful and reliable baseline for understanding the health status of older adults in Eastern India. The findings suggest that improving medication reconciliation and investing in simpler, more patient-friendly drug delivery technologies could help shift healthcare practice away from a culture of “more medicines” toward a more thoughtful approach of “optimal therapy.” Such a shift is not only beneficial for individual patients, but also essential for the long-term sustainability of healthcare systems worldwide.

The study further shows that, among older adults in urban Odisha, medication burden is not merely a consequence of treatment, but a major contributor to clinical complexity. Nearly one third of the participants were living with a high medication burden, and this burden was found to increase the likelihood of multimorbidity by 82% (aOR = 1.82), even after adjustment for other factors. The Population Attributable Fraction of 27.3% is especially striking, as it points to a substantial therapeutic opportunity. In practical terms, it suggests that more effective and rational medication management could potentially reduce a significant share of the overall multimorbidity burden in this population.

For the field of drug delivery and geriatric care, the message is clear: the traditional “one pill for one symptom” approach is becoming increasingly unsustainable. There is a growing need to move from fragmented treatment patterns toward more integrated and patient-centred strategies that emphasize medication reconciliation, fixed-dose combinations, and smarter sustained-release technologies. When treatment is simplified for older adults, the benefit goes beyond controlling disease alone; it can make daily life more manageable and improve overall quality of life. In this way, the study provides a strong evidence-based foundation for future innovations aimed at achieving safer, simpler, and more effective therapy for the ageing population.

Ethical Considerations and Human Participation

This study was conducted in strict accordance with the ethical principles outlined in the Declaration of Helsinki. The study protocol and methodology were formally reviewed and approved by the Institutional Ethics Committee. Participant confidentiality and data protection were rigorously upheld throughout the research process. Given the nature of the community-based survey and the geriatric population involved, the requirement for written informed consent was waived; however, verbal informed consent was obtained from all 1,072 participants prior to their inclusion. The objectives and voluntary nature of the study were thoroughly explained to each participant in their local language before recruitment. No animal subjects or tissues were involved in this research.

Data Availability Statement

The datasets generated and analyzed during the current study are not publicly available due to participant confidentiality agreements and the sensitive nature of the clinical data. However, the data are available from the primary author (Prashansa Das) upon reasonable request and subject to ethical review.

Author Contributions

The authors confirm their contribution to the paper as follows: Prashansa Das: Conceptualization of the study, design of the methodology, primary data collection, statistical analysis, and original draft preparation.Manas Ranjan Behera: Overall supervision, methodology validation, critical results interpretation, and technical editing of the final manuscript. Aurolipy Das: Literature review, technical review of the manuscript, and quality oversight. Deepanjali Behera: Initial manuscript drafting, and reference management. All authors have read and approved the final version of the manuscript for submission.

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Competing Interests
The authors declare that they have no competing financial or personal interests that could have influenced the work reported in this paper.

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