KERALA ECONOMY
2025, VOL. 6, NO.3. pp 47-62

ISSN : 2583-4436

GULATI INSTITUTE OF FINANCE AND TAXATION

# Morbidity and Socio-Economic Burden of Endosulfan in Kerala

Lini.G.R[1] Aiswarya P.V[2]

[1] Assistant Professor, Department of Economics, MG College, Thiruvananthapuram

[2] Research Associate, State Board of Medical Research Central Office, Directorate of Medical Education, Thiruvananthapuram

## Abstract

*The worldwide consumption of pesticides has reached 2.6 million metric tons, of which nearly 85 percent is used in agriculture. Although developed countries account for the largest share, pesticide use is expanding rapidly in developing nations, raising serious public health concerns (WRI, 1999). India, in particular, reports high levels of pesticide residues, which have contributed to severe health-related challenges. In Kerala, the aerial spraying of the highly toxic pesticide endosulfan, without proper safety precautions, has generated widespread vulnerability. Cashew plantations located in mountainous regions were subjected to intensive spraying, and the chemical residues were carried down the slopes during monsoon rains, contaminating local water sources. Continuous consumption of this polluted water resulted in a spectrum of chronic health conditions, including physical deformities, cancers, congenital disorders, and neurological damage.*

*The consequences of endosulfan exposure extend beyond the health domain, creating significant social and economic costs for affected households. Families face high medical expenditures, loss of productive income, dependency on welfare support, and long-term social stigma. These burdens cannot be measured purely in monetary terms, as they encompass diminished quality of life and intergenerational effects. In this context, the present study seeks to identify the morbidity status of endosulfan victims in Kerala and to examine the socio-economic determinants associated with multiple morbidities. The findings aim to*

*provide insights into the intersection of environmental health risks and economic vulnerability, highlighting the need for integrated policy responses.*

***Keywords:*** *Pesticides, Endosulfan, Morbidity, Socio-Economic Burden, Environmental Health, Health Shocks*

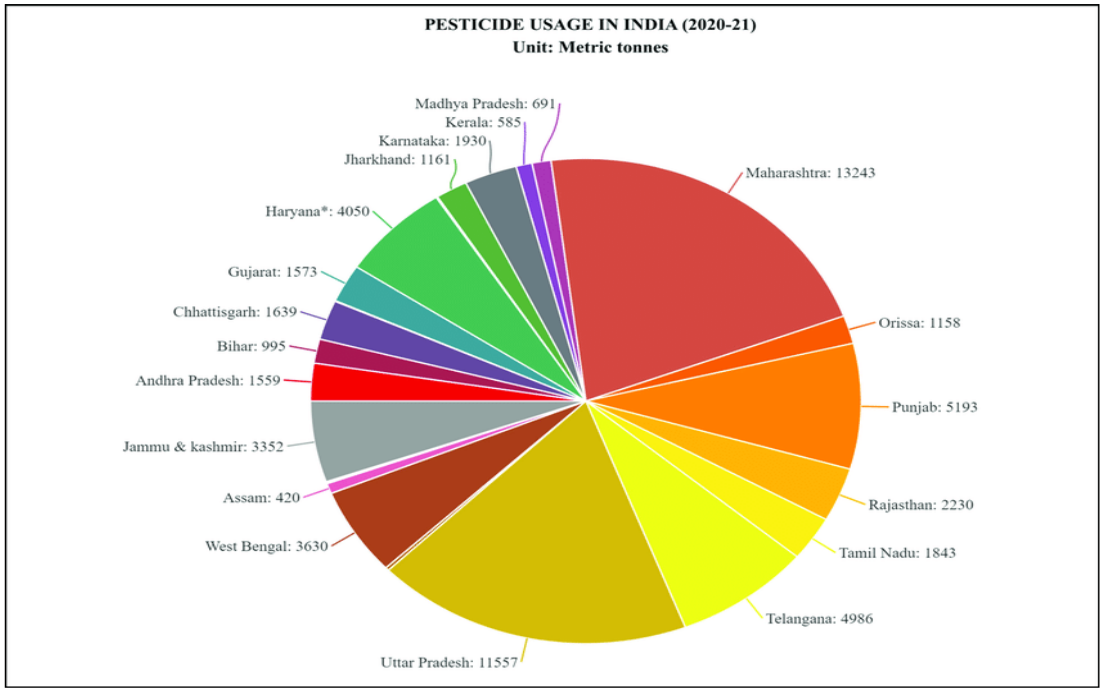
## 1. Introduction

Pesticides have played a crucial role in preventing millions of deaths by controlling pests that transmit diseases such as malaria, bubonic plague, and typhus (Hart & Pimentel, 2002; Pimentel, 2005). While their large-scale application has brought significant benefits, it has also created serious environmental and human health concerns (Mascarelli, 2013). Many insecticides are ineffective in selectively targeting pests and often harm non-target species, producing adverse ecological and health consequences (Horrigan et al., 2002). Consequently, indiscriminate pesticide use has generated considerable socio-economic and environmental externalities (Matyjaszczyk et al., 2019).

Since the 1970s, interdisciplinary research has highlighted the off-farm health and environmental risks of pesticide use, concluding that unchecked chemical reliance in agriculture is neither environmentally sustainable nor socially viable. In particular, indiscriminate insecticide application has been linked to severe health outcomes (Ansari et al., 2014; Nicolopoulou-Stamati et al., 2016), including risks to fetal development (Gilden et al., 2010). Globally, about 41 million people are exposed to pesticides annually (PAN International, 2007). WHO (2009) estimates that pesticide poisoning causes at least 300,000 deaths per year, mostly in low- and middle-income countries. The World Bank (2008) placed this figure at 355,000, while the Pan American Health Organization suggested that 50–80 percent of pesticide poisonings go unreported across the Americas (PAHO, 2011).

In India, pesticides such as insecticides, fungicides, and herbicides are widely used, with insecticides dominating the market. The country is one of the largest producers of pesticides globally, and the market value was estimated at Rs.197 billion in 2018 (Down to Earth).

**Figure 1.** Pesticide Usage in India from 2020-2021




## Endosulfan and negative externality in Kerala

Kerala's model of development has expanded education, healthcare, land reforms, and social security. Yet, sections of the population remain vulnerable, as demonstrated by the tragedy in Kasaragod district, where aerial spraying of endosulfan over cashew plantations for more than two decades exposed thousands to health hazards and ecological damage.

Endosulfan was sprayed thrice yearly, and residues drained downhill during monsoons, contaminating drinking water sources. Continuous exposure led to chronic illnesses, physical deformities, cancers, congenital disorders, and neurological damage. Nearly every household in the affected panchayats reported victims, many permanently disabled or mentally challenged.

The social costs of this crisis extend far beyond measurable healthcare expenses. Externalities include biodiversity loss, groundwater contamination, and productivity decline, which remain uncompensated. The Kerala Plantation Crops Authority primarily considered private costs of plantation output, overlooking long-term health and environmental impacts. This represents a clear case of market failure, where divergence between private and social costs produced devastating negative externalities.

Government interventions have been limited. Medical camps identified 4,273 individuals suffering from nearly 300 types of diseases attributed to endosulfan exposure (GoK, 2011). However, no scientific diagnostic tests were conducted, leaving causal links unproven. As a result, many genuine victims were excluded from official beneficiary lists. This exclusion compounded the externality, as affected families bore health and economic burdens without adequate support.

Thus, the endosulfan tragedy illustrates how unregulated pesticide use can create overlapping health, environmental, and economic damages. Beyond human suffering, it has constrained Kerala's developmental achievements by imposing hidden costs on vulnerable communities. Against this backdrop, the present study seeks to examine the morbidity status of endosulfan victims and analyze correlations between their socio-economic conditions and morbidity pattern.

**Demographic and socio-economic characteristics of the household head**

Table 1 shows the socio-demographic profile of household heads of endosulfan victims in Kasaragod district. The average age was 59.08 years (SD ±1.01). About 22% of victims were from female-headed households. Nearly 70% of household heads were married, 23% widowed, and 6% unmarried. Literacy was reported among 64%.

Almost half were unemployed, while 26% worked without permanent wages. Over half (58%) lived in joint families, usually with 5–10 members. The mean household size was 5.03.

**Table 1.** Background Characteristics of the Head of the Household of Endosulphan Victims

| Background Characteristics | Sample | Percentage |
|---|---|---|
| **Age** | | |
| 35-50 | 78 | 26 |
| 51-60 | 93 | 31 |
| 60+ | 129 | 43 |
| **Sex** | | |
| Male | 234 | 78 |
| Female | 66 | 22 |
| **Marital status** | | |
| Unmarried | 18 | 6 |
| Currently married | 210 | 70 |
| Widow/widower | 69 | 23 |
| Divorced/separated | 3 | 1 |

| | | |
|---|---|---|
| **Educational status** | | |
| Illiterate | 108 | 36 |
| Less than primary education | 63 | 21 |
| Primary education | 51 | 17 |
| Less than secondary education | 30 | 10 |
| Tenth | 36 | 12 |
| Higher Secondary | 9 | 3 |
| | 3 | 1 |
| **Employment status** | | |
| No job | 144 | 48 |
| Self-employed | 3 | 1 |
| Permanently employed | 78 | 26 |
| No permanent wages | 75 | 25 |
| **Household size**(max-10, mini-1) | | |
| 1-4 | 126 | 42 |
| 5-10 | 174 | 58 |

**Demographic characteristics of the victims of endosulfan**

Table 2 presents the demographic profile of endosulfan victims. Females formed 53% of the sample. Respondents ranged from 7–87 years, with a mean age of 44.08 (SD ±2.062). Children comprised 9%, elderly (61+) 27%, and over 60% were in the working-age group.

More than half were married, 28% unmarried, and 17.6% widowed. Among females, 26% were unmarried, 46% married, and 28% widowed, while among males, 29% were unmarried, 64% married, and 7% widowers. Thus, widowed women were nearly four times more than widowed men.

**Table.2** Background characteristics of endosulfan victims

| **Background characteristics** | **Sample** | **Percentage** |
|---|---|---|
| **Age** (max-87, mini-7) | | |
| 7-14 | 27 | 9 |
| 15-24 | 48 | 16 |
| 25-49 | 87 | 29 |
| 50-60 | 57 | 19 |
| 61+ | 81 | 27 |
| **Sex** | | |
| Male | 141 | 47 |
| Female | 159 | 53 |
| **Marital status** * | | |
| Unmarried | 75 | 27.5 |
| Currently married | 150 | 54.9 |

| | | |
|---|---|---|
| Widow | 48 | 17.6 |
| **Education** | | |
| Illiterate | 72 | 24 |
| Primary | 90 | 30 |
| Secondary | 102 | 34 |
| Higher secondary and above | 36 | 12 |
| **Relationship with household head** | | |
| Head of the household | 123 | 41 |
| Wife of the household | 42 | 14 |
| Married daughter/son | 12 | 4 |
| Married son/daughters wife/husband | 39 | 13 |
| Unmarried son/daughter | 72 | 24 |
| Granddaughter /son | 3 | 1 |
| Father mother or father in law or mother in law | 3 | 1 |
| Brother/sister or brother in law/sister in law | 6 | 2 |
| **Employment status** | | |
| Permanently employed | 27 | 9 |
| No permanent wages | 27 | 9 |
| Students | 30 | 10 |
| Others[#] | 216 | 72 |

*not include children <15 years

# others include those who have no job and housewife

**Socio-Economic Characteristics of the Victims**

Table 3 shows the socio-economic profile of endosulfan victims. Most were Hindus (83%), and over 60% belonged to OBCs, followed by SC (18%), ST (7%), and others (11%). Economically, 78% lived below the poverty line and 23% in kutcha houses. Nearly 38% lacked health insurance, making them dependent on out-of-pocket spending for frequent health issues, thereby deepening economic vulnerability.

**Table 3.** Socio-economic background of the victims

| **Background characteristics** | **Sample** | **N(%)** |
|---|---|---|
| **Religion** | | |
| Hindu | 249 | 83 |
| Christian | 3 | 1 |
| Muslim | 48 | 16 |
| **Caste** | | |
| SC | 54 | 18 |
| ST | 21 | 7 |
| OBC | 12 | 64 |
| Others | 33 | 11 |
| **Poverty level** | | |
| Below poverty line | 234 | 78 |
| Above poverty line | 66 | 22 |

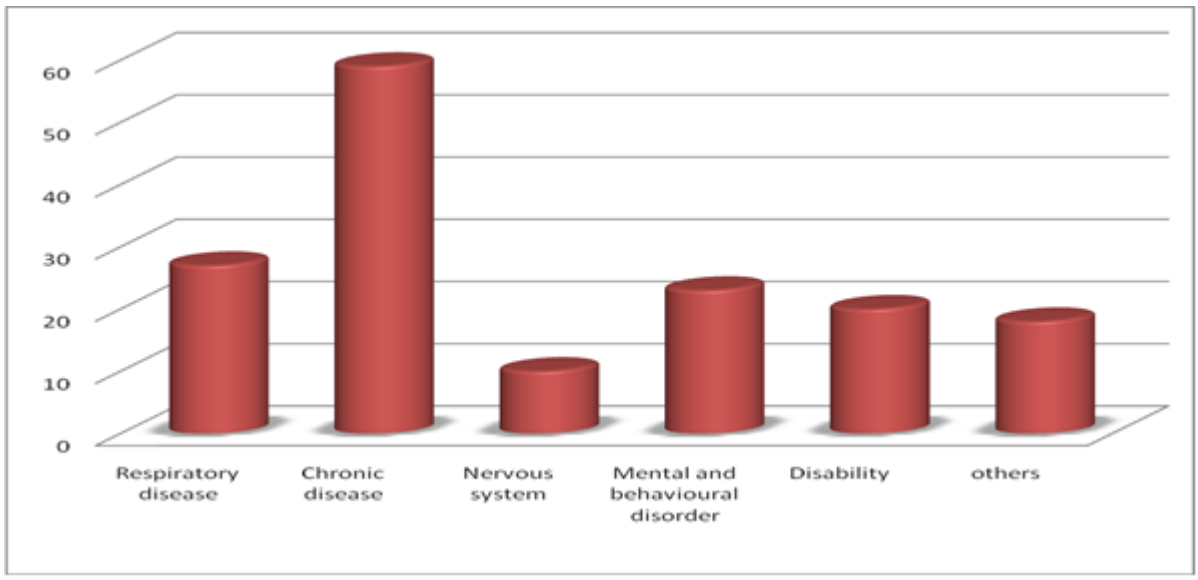
| | | |
|---|---|---|
| **Ownership of house** | | |
| Own | 294 | 98 |
| Rent | 6 | 2 |
| **Type of house** | | |
| Kutcha | 69 | 23 |
| Semi pucca | 168 | 56 |
| Pucca | 63 | 21 |
| **Source of water** | | |
| Own well | 168 | 56 |
| Neighbours well | 45 | 15 |
| Common well | 42 | 14 |
| Others | 45 | 15 |
| **Using of water purification** | | |
| Yes | 189 | 63 |
| No | 111 | 37 |
| **Source for cooking** | | |
| Wood | 102 | 34 |
| Gas(LPG) | 6 | 2 |
| Wood and LPG | 192 | 64 |
| **Have own land** | | |
| Yes | 282 | 94 |
| No | 18 | 6 |
| **How much cent have** | | |
| <10 cent | 42 | 14.9 |
| 10-20 | 60 | 21.3 |
| 20-50 | 39 | 13.8 |
| Above 50 | 141 | 50 |
| **Have health insurance** | | |
| Yes | 186 | 62 |
| No | 114 | 38 |

Regarding basic needs, 56 percent of victims relied on their own wells for domestic water, while 15 percent used common wells and another 15 percent used other sources. About 37 percent did not use any purification methods. Most victims (90%) owned land, with over half holding more than 50 cents. However, 43 percent were excluded from the beneficiary list, leaving many struggling to meet daily needs.

**Morbidity pattern of the endosulfan victims**

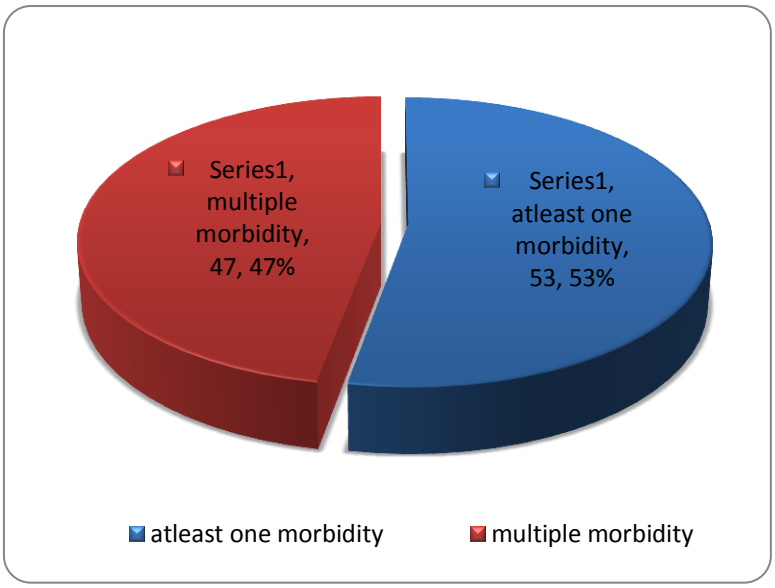
Morbidity generally refers to chronic and age-related diseases. While severity often increases with age, lifestyle changes in modern times have led to morbidity across all age groups. The unscientific and excessive use of pesticides has further contributed to health issues such as infertility, birth defects, attention deficit hyperactivity disorder, diabetes, respiratory diseases, and obesity.

**Figure 3.** Types of Morbidity Suffering by Endosulfan Victims




The morbidity profile of endosulfan victims reveals that 59 percent suffered from chronic illnesses such as diabetes, hypertension, heart disease, paralysis, cancer, or thyroid disorders. Additionally, 27 percent reported respiratory problems, 23 percent mental or behavioral disorders, 20 percent disabilities, 10 percent neurological issues, and 18 percent other conditions including joint pain, infertility, obesity, or piles. Overall, 53 percent had some form of morbidity, with 40 percent experiencing two morbidities and 7 percent facing three or more

**Figure 4.** Morbidity Pattern of Endosulphan Victims



**Demographic, socio-economic association with morbidity status among the victims of endosulfan**

Socio-economic disadvantage is a major factor in disease occurrence. In Kasaragod, poor conditions and low awareness have led to widespread single and multiple morbidities among endosulfan victims. Table 4 shows that single morbidity was more common across age groups, while multiple morbidities peaked (59.3%) among those 61+. Single morbidity dominated in both low and high socio-economic groups, whereas multiple morbidities were higher in the medium group. By gender, 55.3% of males reported multiple morbidities, while 60.4% of females had single morbidity. Direct causes were mainly linked with single morbidity, whereas indirect causes corresponded to multiple morbidities

**Table 4.** Demographic, socio-economic association with morbidity status among the victims of endosulphan

| Background characteristics | At least one morbidity | Two or more morbidity |
|---|---|---|
| **Age of the victim** | | |
| 7-14 | 77.8 | 22.2 |
| 15-24 | 56.2 | 43.8 |
| 25-49 | 51.7 | 48.3 |
| 50-60 | 57.9 | 42.1 |
| 61+ | 40.7 | 59.3 |
| **Standard of living index** | | |
| Low | 57.4 | 42.6 |
| Medium | 41.90 | 58.1 |
| High | 60.0 | 40.0 |
| **Marital status** | | |
| Unmarried | 52.0 | 48.0 |
| Currently married | 48.0 | 52.0 |
| Widow/widower/Divorced/separated | 56.2 | 43.8 |
| **House hold size** | | |
| 1-4 | 54.8 | 45.2 |
| 5-10 | 51.7 | 48.3 |
| **Sex** | | |
| Male | 44.7 | 55.3 |
| Female | 60.4 | 39.6 |
| **Marital status** | | |
| Unmarried | 52.0 | 48 |
| Currently married | 48 | 52 |
| Widow | 56.2 | 43.8 |
| **Religion** | | |
| Hindu | 51.8 | 48.2 |
| Christian | 0 | 100 |
| Muslim | 62.5 | 37.5 |

| Background characteristics | At least one morbidity | Two or more morbidity |
|---|---|---|
| **Caste** | | |
| SC | 44.4 | 55.6 |
| ST | 57.1 | 42.9 |
| OBC | 57.8 | 42.2 |
| Others | 36.4 | 63.6 |
| **Poverty line** | | |
| yes | 51.3 | 48.7 |
| **Ownership of house** | | |
| Own | 52.0 | 48.0 |
| rent | 100 | 0 |
| **Type of house** | | |
| Kutcha | 34.8 | 65.2 |
| Semi pucca | 53.6 | 46.4 |
| pucca | 71.4 | 28.6 |
| **Water purification before use** | | |
| Yes | 52.4 | 47.6 |
| No | 54.1 | 45.9 |
| **Source of cooking** | | |
| Wood | 41.2 | 58.80 |
| Gas(LPG | 50 | 50. |
| Both wood and gas | 59.4 | 40.6 |
| **Reason to have the disease** | | |
| Direct relation | 56.6 | 43.4 |
| Indirect relation | 41.7 | 58.3 |
| **Have Medical allowance** | | |
| Yes | 47.2 | 52.8 |
| No | 59.6 | 40.4 |

The table shows that single morbidity declines with age, while multimorbidity rises, reaching 59% among those aged 60+. Over three-fourths of single morbidity cases occur in the 7–14 age group. Multimorbidity is lower (40%) among high living-standard households but increases, along with single morbidity, as household size grows. By gender, females report more single morbidity (60%), whereas males report more multimorbidity (55%). Caste-wise, single morbidity is highest among Scheduled Tribes and OBCs, while multimorbidity is most common among Forward Castes.

**Table 5.** Socio economic and demographic correlates of multiple morbidity among endosulfan victims

| Background characteristics | Exp(B) | Sig | 95% C.I.for EXP(B) | |
|---|---|---|---|---|
| | | | Lower | Upper |
| **Age** | | | | |
| 17-14® | | | | |
| 15-24 | 7.184 | 0.000 | 3.808 | 8.456 |
| 25-49 | 0.297 | 0.191 | 0.048 | 1.833 |
| 50-60 | 6.362 | 0.032 | 1.276 | 9.744 |
| 61+ | 9.134 | 0.000 | 7.306 | 10.480 |
| **Sex** | | | | |
| Male® | | | | |
| Female | 0.007 | 0.000 | 0.001 | 0.037 |
| **Marital status** | | | | |
| Unmarried® | | | | |
| Currently married | 5.852 | 0.059 | 0.935 | 36.618 |
| Widow | 7.467 | 0.007 | 2.773 | 8.678 |
| **Education** | | | | |
| Illiterate ® | | | | |
| Primary | 1.535 | 0.495 | 0.449 | 5.244 |
| Secondary | 1.447 | 0.593 | 0.373 | 5.605 |
| Higher secondary and above | 10.899 | 0.010 | 1.764 | 17.337 |
| **Employment status** | | | | |
| Permanently employed® | | | | |
| No permanent wages | 1.360 | 0.006 | 1.329 | 4.760 |
| Students | 1.410 | 0.669 | 0.292 | 6.805 |
| Others[#] | 5.976 | 0.003 | 3.083 | 8.853 |
| **Religion** | | | | |
| Hindu® | | | | |
| Christian | 1.842 | 0.999 | 0.000 | 2.258 |
| Muslim | 2.272 | 0.000 | 1.131 | 3.316 |
| **Caste** | | | | |
| SC® | | | | |
| ST | 0.080 | 0.026 | 0.009 | 0.743 |
| OBC | 0.411 | 0.268 | 0.085 | 1.985 |
| Others | 1.437 | 0.686 | 0.248 | 8.325 |
| **Poverty level** | | | | |
| Below poverty line® | | | | |
| Above poverty line | 0.318 | 0.037 | 0.108 | 0.935 |
| **Type of house** | | | | |
| Kutcha® | | | | |
| Semi pucca | 0.022 | 0.000 | 0.004 | 0.113 |
| Pucca | 0.004 | 0.000 | 0.000 | 0.040 |
| **Source of water** | | | | |
| Own well® | | | | |

| Background characteristics | Exp(B) | Sig | 95% C.I.for EXP(B) | |
|---|---|---|---|---|
| | | | Lower | Upper |
| Neighbours well | 0.359 | 0.141 | 0.092 | 1.404 |
| Common well | 0.083 | 0.005 | 0.015 | 0.477 |
| Others | 0.016 | 0.000 | 0.003 | 0.097 |
| **Using of water purification** | | | | |
| Yes® | | | | |
| No | 2.172 | 0.000 | 1.007 | 5.124 |
| **Source for cooking** | | | | |
| Wood® | | | | |
| Gas(LPG) | 2.940 | 0.443 | 0.186 | 4.376 |
| Wood and LPG | 0.350 | 0.125 | 0.092 | 1.336 |
| **Have health insurance** | | | | |
| Yes® | | | | |
| No | 0.060 | 0.000 | 0.020 | 0.173 |

® Reference Category

Table 5 shows binary logistic regression results on socio-economic and background factors affecting multiple morbidity among endosulfan victims. The risk is higher among ages 15–24 and 50+ compared to below 14 years, and among males than females. Widows/widowers are about seven times more likely to suffer multiple morbidity than the unmarried (CI: 2.773–8.678, significant). Victims without purified water face over twice the odds (OR: 2.172, CI: 1.007–5.124).

## Conclusion

The study clearly demonstrates that the indiscriminate use of endosulfan in Kasaragod district has resulted in profound and long-lasting health, social, and economic consequences. The findings reveal a high prevalence of morbidity and multimorbidity among victims, particularly among the elderly, widowed, and socio-economically disadvantaged groups. Despite Kerala's commendable achievements in human development, the endosulfan tragedy underscores how lapses in environmental governance and inadequate regulation of chemical use can generate devastating negative externalities that erode public health gains and deepen social inequities. The results highlight that exposure to environmental toxins such as endosulfan not only affects individuals' physical health but also imposes far-reaching economic and emotional burdens on affected families and communities.

The analysis further indicates that demographic and socio-economic characteristics-such as age, marital status, educational level, housing condition, access to safe drinking water, and

health insurance coverage-are significantly associated with multiple morbidity among victims. The lack of clean water and inadequate healthcare protection have aggravated health risks, trapping many households in a cycle of illness and poverty. These findings call for stronger policy interventions that integrate environmental safeguards with public health planning. Comprehensive rehabilitation programs, effective compensation mechanisms, and promotion of eco-friendly pest management are essential to mitigate the long-term impacts of such disasters. The study thus reinforces the urgent need for a sustainable development approach that prioritizes human health and ecological integrity alongside agricultural productivity.

**Policy recommendations:**

**1. Strengthen Environmental and Pesticide Regulation:**

The endosulfan tragedy highlights the urgent need for stricter enforcement of pesticide regulation in India. Policies should mandate periodic monitoring of pesticide residues in soil, water, and crops, and ensure that only eco-friendly and WHO-recommended chemicals are permitted. The Central Insecticides Board and Registration Committee (CIBRC) must strengthen its post-approval surveillance mechanisms, and state-level monitoring cells should be empowered to ban harmful substances immediately upon evidence of health risks.

**2. Promote Sustainable and Integrated Pest Management (IPM):**

To reduce dependency on chemical pesticides, agricultural policies should promote Integrated Pest Management (IPM), organic farming, and bio-control alternatives. Training programs for farmers through Krishi Vigyan Kendras (KVKs) and agricultural extension services should emphasize safe pesticide handling, appropriate dosage, and the long-term economic benefits of non-chemical pest control methods.

**3. Comprehensive Health Surveillance and Medical Support:**

Establishing a long-term health surveillance system for pesticide-exposed communities is essential. The government should set up specialized medical centers in affected regions for continuous screening, treatment, and rehabilitation of victims. Free medical check-ups, mental health services, and mobile health units must be made available to ensure accessibility for marginalized and remote populations.

**4. Targeted Socio-Economic Rehabilitation Programs:**

Many endosulfan-affected families continue to suffer financial distress due to chronic illness and disability. The government should ensure comprehensive compensation schemes, disability pensions, and livelihood support programs. Special provisions for education and skill development for victims and their dependents can help restore economic independence and social dignity.

**5. Improved Access to Clean Water and Sanitation:**

Given the strong association between water contamination and morbidity, policies should prioritize access to safe drinking water in all pesticide-affected regions. The installation of community-based purification systems, rainwater harvesting, and regular water quality testing should be institutionalized under the National Rural Drinking Water Programme.

**6. Expand Health Insurance and Social Protection Coverage:**

Victims of environmental exposure often lack adequate financial protection against medical expenses. Expanding government-sponsored health insurance schemes such as Ayushman Bharat to include chronic pesticide-related illnesses can prevent further impoverishment of vulnerable families. Dedicated funds should be established for emergency medical aid and rehabilitation.

**7. Community Awareness and Participatory Governance:**

Strengthening community participation in environmental decision-making is vital. Awareness campaigns should educate local communities on the risks of pesticide misuse, safe agricultural practices, and available health services. Empowering Panchayat Raj Institutions to monitor local environmental health issues can foster accountability and ensure early intervention.

**8. Research and Data-Driven Policy Planning:**

Continuous interdisciplinary research is needed to assess the long-term ecological and health effects of pesticides. Establishing a national database on pesticide exposure, health outcomes, and compensation status can aid policymakers in designing evidence-based interventions and preventive measures.

## References

Ajay, A. (2024). *A study on the social and environmental impact of Edayar industrial units in Ernakulam* (Master's thesis, St. Teresa's College [Autonomous], Ernakulam).

Ansari, R. A., Kaur, M., & Ahmad, S. (2014). Insecticides: Impact on the environment and human health. In R. Arora & R. S. Srivastava (Eds.), *Environmental deterioration and human health* (pp. 99–123). Springer. https://doi.org/10.1007/978-94-007-7890-0_6

Bonvoisin, T., Utyasheva, L., Knipe, D., Gunnell, D., & Eddleston, M. (2020). Suicide by pesticide poisoning in India: A review of pesticide regulations and their impact on suicide trends. *BMC Public Health, 20,* 251. https://doi.org/10.1186/s12889-020-8339-z

Gilden, R. C., Huffling, K., & Sattler, B. (2010). Pesticides and health risks. *Journal of Obstetric, Gynecologic & Neonatal Nursing, 39*(1), 103–110. https://doi.org/10.1111/j.1552-6909.2009.01092.x

Government of Kerala. (2011, April 20). *Report on health effects of endosulfan and progress of rehabilitation activities in Kerala*. Department of Health and Family Welfare. http://www.endosulphan.in/wp-content/docs/endosulfan.keralastory.pdf

Kumar, N. (n.d.). *The usage of insecticides in agriculture in Odisha, India: An assessment of sources and controls of exposure and associated health risks in rice farmers and farmworkers* (Doctoral dissertation, University of Newcastle, Australia).

Matyjaszczyk, E., et al. (2019). How European Union accession and implementation of obligatory integrated pest management influenced forest protection against harmful insects: A case study from Poland. *Forest Ecology and Management, 433,* 146–152. https://doi.org/10.1016/j.foreco.2018.11.001

Nicolopoulou-Stamati, P., Maipas, S., Kotampasi, C., Stamatis, P., & Hens, L. (2016). Chemical pesticides and human health: The urgent need for a new concept in

agriculture. *Frontiers in Public Health, 4,* 148. https://doi.org/10.3389/fpubh.2016.00148

PAN Asia Pacific. (n.d.). *Global governance of hazardous pesticides to protect children: Beyond 2020*. PAN Asia Pacific. https://panap.net

Sony, R. K., Münster, D., & Krishnan, S. (2023). What counts as evidence? Examining the controversy over pesticide exposure and etiology in an environmental justice movement in Kerala, India. *Environmental Sociology, 9*(2), 148–164. https://doi.org/10.1080/23251042.2022.2116768

Sree Kumar, S., & Prathapan, B. (2021). An evidence-based inquiry into the Endosulfan tragedy in Kasaragod, Kerala. *Economic and Political Weekly, 56*(41), 37–44.

Stamati, L., Kolialexi, A., & Gounaris, A. (2016). Chemical pesticides and human health: The urgent need for a new concept in agriculture. *Environmental Health and Exposome (Public Health)*, July 2016.

Thomas, N. (2015). *An economic analysis of biopesticide use in paddy farms of Kerala* (Master's thesis, Tamil Nadu Agricultural University, Coimbatore). Tamil Nadu Agricultural University.