

Invisible spores, visible strain: Indoor mold as a neglected determinant of mental health

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Abstract

Indoor mold exposure is an underrecognized environmental determinant of mental health. While the respiratory impacts of mold have long been established, its subtle neuropsychological consequences are increasingly drawing attention. Evidence from Europe, North America, and emerging African studies indicates that chronic exposure to damp, mold-infested dwellings may elevate risks of depression, anxiety, cognitive dysfunction, and sleep disturbance. These outcomes are often exacerbated by socioeconomic stressors and inadequate housing infrastructure, which are common in tropical and low-income settings. This short communication explores current evidence, underlying mechanisms, and illustrative global cases, including observations from humid African regions, to highlight the mental-health burden of mold exposure. Addressing the “invisible spores” that silently undermine psychological resilience demands an integrated housing, environmental, and mental-health response.

Keywords: mold exposure, damp housing, neuroinflammation, depression, indoor environment.

Esporos invisíveis, sofrimento visível: o mofo em ambientes internos como um determinante negligenciado da saúde mental

Resumo

A exposição ao mofo em ambientes internos é um determinante ambiental da saúde mental ainda pouco reconhecido. Embora os impactos respiratórios do mofo sejam há muito estabelecidos, suas consequências neuropsicológicas sutis vêm recebendo atenção crescente. Evidências provenientes da Europa, da América do Norte e de estudos emergentes na África indicam que a exposição crônica a ambientes úmidos e infestados por mofo pode aumentar os riscos de depressão, ansiedade, disfunção cognitiva e distúrbios do sono. Esses efeitos são frequentemente agravados por fatores socioeconômicos e pela inadequação da infraestrutura habitacional, condições comuns em regiões tropicais e de baixa renda. Esta comunicação breve explora as evidências atuais, os mecanismos subjacentes e casos ilustrativos de diferentes regiões do mundo, incluindo observações de áreas africanas úmidas, com o objetivo de destacar a carga sobre a saúde mental associada à exposição ao mofo. Enfrentar os “esporos invisíveis” que silenciosamente comprometem a resiliência psicológica exige uma resposta integrada envolvendo habitação, meio ambiente e saúde mental.

Palavras-chave: exposição ao mofo, habitação úmida, neuroinflamação, depressão, ambiente interno.

1. Introduction

Indoor air quality, particularly in relation to dampness and fungal proliferation, remains an underexplored yet important determinant of mental health, especially in LMIC contexts. In most low- and middle-income countries

(LMICs), public-health interventions emphasize infectious diseases, water safety, and sanitation (Besnier et al., 2021; Dicker et al., 2017; Murray et al., 2017), while the mental consequences of poor housing receive limited attention. Yet, daily exposure to moisture-damaged environments can subtly erode both physiological and psychological well-being (Genuis et al., 2025; Moss, 2023).

Historically, mold exposure research has focused on respiratory illnesses, chronic cough, asthma exacerbation, and hypersensitivity pneumonitis (Adams et al., 2025; Borchers et al., 2017; McDonell; Aronica, 2022; Mendell et al., 2011). However, a growing body of evidence suggests that mold exposure may also contribute to depressive symptoms, chronic fatigue, impaired concentration, and anxiety disorders (Ehsanifar et al., 2023; Gauvin, 2023; Ratnaseelan; Tsilioni, 2018). These findings warrant urgent investigation, particularly in tropical regions such as Sierra Leone, Nigeria, Ghana, and Liberia, where high humidity, poor ventilation, and low-cost construction materials create ideal conditions for indoor dampness (Aleem, 2021; Bakare, 2021; Busolo; Njabira, 2022).

In these contexts, mold exposure is not just a biological hazard; it is a social and psychological burden that reflects inequities in housing, income, and public health infrastructure (Gauvin, 2023). This paper highlights the neglected role of mold as a determinant of mental health and calls for policy recognition of indoor environmental quality within broader health frameworks. This paper synthesizes emerging evidence on indoor mold exposure as a neglected determinant of mental health and underscores the need to integrate indoor environmental quality into broader public-health and housing policy frameworks, particularly in tropical LMIC settings.

This manuscript draws on peer-reviewed literature published between 2000 and 2024 on mold exposure, damp housing, mental health outcomes, and tropical environmental conditions. Evidence was identified through searches in PubMed, Google Scholar, and Scopus using terms such as “mold,” “damp housing,” “mental health,” “neuroinflammation,” “LMIC,” and “tropical environments.” African-specific studies were intentionally prioritized where available. This is not a systematic review but a narrative evidence synthesis.

2. Conceptual Framework: Biological, Psychological, Social Pathways Linking Mold Exposure to Mental Health

Indoor mold exposure may influence mental health through interconnected biological, psychological, and social pathways, including immune activation, neuroinflammatory processes, chronic stress, and housing-related psychosocial strain. These interrelated mechanisms are summarized in the conceptual framework presented in (Figure 1), which illustrates the hypothesized pathways linking indoor mold exposure to adverse mental health outcomes.

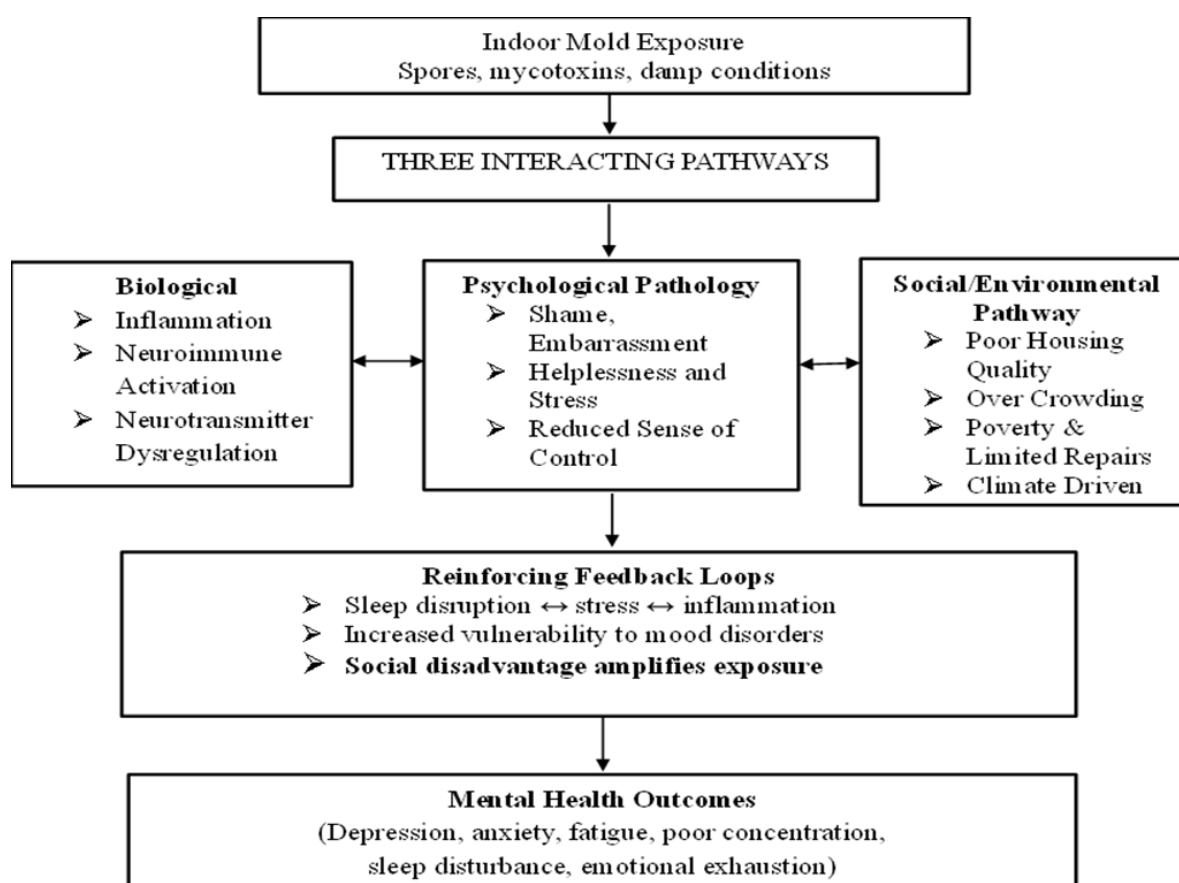


Figure 1. Integrated pathway linking indoor mold exposure to mental health outcomes. Source: Authors, 2026.

To clarify how indoor mold influences mental health outcomes, this communication adopts an integrated conceptual model that brings together biological, psychological, and social mechanisms into a single interactive pathway. These mechanisms do not function independently; rather, they intersect and reinforce one another, producing cumulative and often cyclical effects on mental well-being. Such interactions are especially pronounced in environments marked by poor housing quality, chronic dampness, and prolonged exposure to environmental stressors.

2.1 Biological Pathway

Indoor mold releases spores and mycotoxins that can trigger inflammation, oxidative stress, allergic reactions, and neuroimmune activation (Ratnaseelan et al., 2018). These biological processes can disrupt key neurotransmitter systems, particularly those involved in regulating mood, energy, cognition, and sleep. As a result, individuals exposed to mold-contaminated environments may experience symptoms such as persistent fatigue, anxiety, low mood, sleep disturbances, and difficulties with attention and concentration (Harding et al., 2023).

2.2 Psychological Pathway

Living in visibly deteriorating or persistently damp environments can take an emotional toll. People often feel a sense of shame or embarrassment about their living conditions, coupled with frustration, helplessness, and a loss of control. Over time, being surrounded by such conditions can intensify stress, make individuals more emotionally vulnerable, and gradually erode their sense of resilience and well-being (Ratnaseelan et al., 2018; Wang et al., 2021).

2.3 Social and Environmental Pathway

Housing insecurity, overcrowding, poverty, and weak infrastructure can magnify the impact of mold exposure. When people are already struggling with financial pressures, limited options for safe housing, or long delays in accessing repairs, the stress becomes even heavier. These social burdens combined with feelings of being overlooked or neglected by landlords, services, or the wider community can deepen emotional distress and make it harder for individuals and families to cope effectively (Felger, 2017; Vaid; Evans, 2017).

These pathways do not stand alone; they interact in constant, dynamic ways. Biological reactions to mold can heighten a person's sensitivity to stress, making everyday challenges feel heavier (Bastos et al., 2023; Ratnaseelan et al., 2018). In turn, ongoing psychological distress can worsen sleep problems and even fuel further inflammation, creating a difficult cycle to break (Bastos et al., 2023; Fisk et al., 2010; Gatto et al., 2024). Social disadvantage then compounds these effects by increasing exposure to mold and limiting the resources people need to fix the problem (Abimbola; Olubunmi, 2023; Felger, 2017; Fisk et al., 2010). Recognizing how these forces intertwine is crucial for developing interventions that truly meet the needs of communities living in resource-constrained settings.

2.4 Evidence from global and African contexts

Evidence from global and African contexts suggests that the relationship between indoor mold exposure and mental health is shaped by differences in housing conditions, environmental exposure, study designs, and socioeconomic circumstances. Although evidence from Europe, North America, and Oceania is relatively more established, African evidence remains predominantly observational and highlights important gaps in exposure assessment, longitudinal research, and mental-health evaluation. The main similarities, differences, and evidence gaps across these contexts are summarized in (Table 1).

Table 1. Summary of global and African evidence linking indoor mold exposure to mental health outcomes.

Evidence Domain	Global Evidence (Europe, North America, Oceania)	African Evidence (LMIC & Tropical Contexts)	Key Evidence Gaps
Study Designs	Large cross-sectional surveys, reviews, and longitudinal cohort studies examining housing conditions and mental health (Howden-Chapman et al., 2021; Mendell et al., 2011; Shenassa et al., 2007).	Predominantly cross-sectional studies, environmental health assessments, and community-based observations (Abimbola; Olubunmi, 2023; Aleem, 2021; Zakariyyah et al., 2020).	Lack of longitudinal and intervention studies in African settings
Housing Context	Damp or mold-infested homes in temperate climates; older housing stock; rental housing (Wang et al., 2020).	Poor-quality housing, informal settlements, limited ventilation, climate-driven dampness (Aleem, 2021; Busolo; Njabira, 2022).	Limited standardized housing-quality metrics adapted for tropical LMICs
Mental Health Outcomes Reported	Depression, anxiety, psychological distress, emotional exhaustion, sleep disturbance, cognitive fatigue (Riemann et al., 2017; Shenassa et al., 2007; Wang et al., 2020).	Depressive symptoms, sleep difficulty, emotional distress, irritability, reduced motivation (Bastos et al., 2023; Ratnaseelan et al., 2018)	Scarcity of validated mental-health screening tools used alongside environmental exposure data
Strength of Evidence	Strong and consistent associations across countries; some evidence of dose-response relationships (Fisk et al., 2010; Mendell et	Emerging but contextually consistent associations; evidence largely observational (Aleem, 2021; Gauvin,	Limited causal inference and absence of exposure quantification

	al., 2011)	2023).	
Biological Mechanisms	Neuroinflammation, immune activation, mycotoxin exposure, neurotransmitter dysregulation supported by experimental and epidemiologic studies (Bastos et al., 2023; Felger, 2017; Fisk et al., 2010; Harding et al., 2023; Ratnaseelan et al., 2018).	Similar mechanisms hypothesized, but few biomarker or toxicological studies conducted locally	Lack of biomarker-based and experimental studies in African populations
Psychosocial Pathways	Housing-related stress, loss of control, chronic discomfort contributing to depression and anxiety (Gauvin, 2023; Vaid; Evans, 2017).	Psychosocial stress amplified by poverty, housing insecurity, overcrowding, and limited repair options (Bastos et al., 2023; Ratnaseelan et al., 2018).	Limited qualitative research capturing lived experiences of mold exposure
Policy Recognition	Indoor air quality and dampness addressed in housing and health regulations (Carlos et al., 2017; Vaid; Evans, 2017; WHO, 2009).	Minimal policy linkage between housing quality, indoor environment, and mental health	Absence of explicit mental-health framing in housing and environmental health policies
Overall Implication	Mold recognized as a modifiable environmental risk factor for mental health (Bastos et al., 2023; Carlos et al., 2017; Harding et al., 2023; Ratnaseelan et al., 2018; Vaid; Evans, 2017).	Mold remains a neglected but preventable determinant of mental health	Need for integrated housing-environment-mental health research and policy frameworks

Source: Authors, 2026.

Empirical evidence linking residential dampness, indoor mold exposure, and mental health outcomes has been documented across diverse geographical and socioeconomic settings. Table 1 provides a summary of key studies from global and African contexts, highlighting reported associations between mold exposure, psychosocial stressors, and mental health outcomes. Research across continents has revealed a persistent association between damp or mold-infested housing and poor mental health outcomes (Aleem, 2025; Borchers et al., 2017; Ehsanifar et al., 2023; Gauvin, 2023).

In a cross-national study covering eight European countries, researchers found that individuals living in visibly moldy homes were 39% more likely to experience depression than those in mold-free homes (Shenassa et al., 2007). Additionally, a New Zealand longitudinal study reported that participants residing in damp homes were significantly more likely to develop psychological distress and report lower life satisfaction (Howden-Chapman et al., 2021). Similarly, researchers in Europe observed that individuals exposed to chronic indoor dampness reported higher rates of emotional exhaustion, sleep problems, and anhedonia (Riemann et al., 2017; Wang et al., 2020), and a State-of-the-Science Review also reported that indoor mold exposure is associated with depression, stress, and anxiety for adults, whilst children experienced emotional symptoms and dysregulation (Gatto et al., 2024).

In tropical Africa, local environmental health assessments have identified similar links. A 2023 Nigerian study in Lagos reported that 46% of residents in waterlogged communities experienced recurrent depressive episodes and sleep difficulty, with visible mold as a common feature (Abimbola; Olubunmi, 2023). In Sierra Leone's Bo District, community health workers describe recurring 'musty-smelling homes' where residents often complain of low motivation and irritability symptoms that may reflect chronic environmental exposure.

3. Mechanistic Pathways Linking Mold to Mental Health

3.1 Biological and Neuroinflammatory Mechanisms: Certain molds like *Trichoderma*, *Fusarium*, and *Stachybotrys* spp release mycotoxins that can provoke systemic inflammation and neuroimmune activation (Ratnaseelan et al., 2018). Chronic exposure may alter neurotransmitter function, particularly serotonin and dopamine pathways that regulate mood. Animal studies demonstrate that exposure to *Stachybotrys chartarum* induces anxiety-like behavior and learning impairment (Felger, 2017; Fisk et al., 2010; Harding et al., 2023).

3.2 Psychosocial and Environmental Stressors: Living in visibly deteriorating housing can evoke feelings of shame and helplessness, which predict depression (Vai; Evans, 2017). In informal settlements, residents often face double exposure: physical illness due to mold and emotional exhaustion from unaddressed housing decay (Ratnaseelan et al., 2018).

3.3 Sleep Disruption and Cognitive Fatigue: Mold exposure has been linked to sleep disorders through allergic congestion and breathing difficulty (Carlos et al., 2017; Wang et al., 2020; Wang et al., 2022). Poor sleep intensifies irritability, anxiety, and poor concentration, creating a feedback loop between environmental exposure and mental distress (Maria et al., 2023).

4. Illustrative Case: Damp Homes in Tropical Bo City, Sierra Leone

Bo City, located in southern Sierra Leone, lies within a humid tropical climatic zone characterized by persistently high relative humidity and a prolonged rainy season (Johnny, 2025). Southern and Eastern Sierra Leone experience high annual rainfall and sustained ambient humidity, particularly during the May-October rainy season, conditions that are widely recognized as conducive to indoor dampness and fungal proliferation (Ishizawa et al., 2020; Manson; Knight, 2025). In tropical environments, prolonged moisture exposure within dwellings increases the likelihood of condensation, mold growth, and microbial persistence on interior walls and household materials (Carlos et al., 2017; Vaid; Evans, 2017).

Residential housing in Bo City is commonly constructed using porous cement blocks, mud-brick, or sandcrete, often without damp-proof courses, effective drainage systems, or adequate ventilation (Mason; Knight, 2025). Such construction characteristics are repeatedly identified in low-income tropical settings as major structural drivers of indoor dampness and mold growth (Aleem, 2021; Vaid; Evans, 2017). During the rainy season, repeated water ingress through walls, roofs, and floors leads to chronic moisture retention, visible fungal growth, and persistent musty odors (Ishizawa et al., 2020). Limited access to affordable waterproofing materials and constrained household incomes further reduce residents' capacity to remediate damp conditions once established (Busolo; Njabira, 2022).

Despite these environmental realities, national housing and public health policies in Sierra Leone do not explicitly recognize indoor dampness or mold exposure as health risks, particularly with respect to mental health (Ishizawa et al., 2020; Manson; Knight, 2025). Existing housing and urban development frameworks largely emphasize structural safety and land tenure, with minimal attention to indoor environmental quality, ventilation standards, or moisture control (Sovacool, 2025). Similarly, mental health policy frameworks focus primarily on service provision and workforce development (Colizzi et al., 2020; Furber et al., 2015; Juma et al., 2020), while upstream environmental determinants such as housing quality remain under-integrated (Abdi-Dekhordi et al., 2021). This policy-disconnect leaves communities exposed to a preventable environmental stressor that remains largely invisible within formal health surveillance and intervention systems.

Climate change is expected to exacerbate these risks. Projections for West Africa indicate increasing rainfall variability, more intense precipitation events, and rising temperatures, all of which are likely to worsen indoor dampness, flooding, and housing deterioration in poorly constructed dwellings (Carlos et al., 2017; Ishizawa et al., 2020; Vaid; Evans, 2017). In this context, mold exposure represents a climate-sensitive pathway linking environmental change to mental health vulnerability, particularly in low-income urban and peri-urban communities where adaptive housing infrastructure is limited (Sheehan, 2024). Climate-driven increases in damp housing may therefore silently expand populations at risk of depression, anxiety, sleep disturbance, and emotional exhaustion (Gauvin, 2023).

The Bo City case thus illustrates how climatic conditions, housing policy gaps, and climate change interact to

sustain exposure to indoor mold, with potential implications for psychological well-being. Although systematic epidemiological data remain limited, community-level observations in Sierra Leone and comparable tropical settings consistently describe symptoms such as fatigue, irritability, low motivation, and sleep disturbance among residents of damp homes, patterns that mirror findings from global studies linking mold exposure to mental health outcomes (Fisk et al., 2010; Shenassa et al., 2007).

5. Implications for Future Research

This illustrative case highlights several priorities for future research. First, studies integrating meteorological data (rainfall and humidity), housing assessments, and validated mental health measures are needed to quantify exposure-response relationships in tropical LMIC contexts. Second, longitudinal and mixed-methods research would help clarify temporal and causal pathways linking chronic dampness, psychosocial stress, and mental health outcomes. Third, policy-oriented research should examine how housing standards, climate adaptation strategies, and mental health frameworks can be better aligned to address indoor environmental risks. Finally, evaluations of low-cost, climate-resilient housing interventions should incorporate mental health outcomes alongside physical health indicators to capture their full public-health impact.

6. Policy and Public-Health Implications

Addressing the mental-health burden associated with indoor mold exposure requires practical, multi-sectoral policy action that links environmental health, housing, and community-level prevention (Furber et al., 2015). First, indoor air quality should be formally integrated into national Environmental Health and Public Health policies, with explicit recognition of dampness and mold as health hazards. This integration would align environmental health surveillance with mental-health promotion and enable routine monitoring of housing-related risks within existing public-health systems (Carlos et al., 2017).

Second, local building codes and housing standards should be reviewed and updated to include minimum requirements for ventilation, moisture control, drainage, and climate-resilient construction. In rapidly urbanizing settings, enforcement mechanisms should prioritize rental housing and informal settlements, where exposure risk is highest (Maria et al., 2023; Wang et al., 2021).

Third, community-level ventilation and housing-maintenance education should be introduced through environmental health officers, community health workers, and local councils. Simple messages on window use, airflow management, early dampness detection, and safe cleaning practices can substantially reduce indoor moisture accumulation (Carlos et al., 2017; Vaid; Evans, 2017).

Finally, low-cost, context-appropriate interventions applicable to Sierra Leonean homes should be promoted, including improved roof overhangs, basic wall sealing, raised floor levels in flood-prone areas, use of locally available ventilation openings, and routine sun-drying of interior spaces. Collectively, these measures represent feasible, preventive strategies for reducing mold exposure and protecting mental well-being in resource-constrained settings.

7. Call for action

Indoor mold exposure constitutes a preventable, climate-sensitive environmental determinant of mental health that remains insufficiently addressed in tropical low- and middle-income countries. Consistent with WHO guidance on healthy housing and indoor air quality and UN-Habitat's emphasis on adequate, resilient housing, there is an urgent need to integrate indoor environmental quality into mental health, housing, and climate-adaptation frameworks (Fisk et al., 2010; Vaid; Evans, 2017; WHO, 2009; Zakariyyah et al., 2020).

Research priorities should focus on generating robust African epidemiologic evidence through population-based studies linking damp housing and mold exposure to validated mental-health outcomes, supported by longitudinal and mixed-methods designs. Integrating meteorological indicators (rainfall, humidity, flooding) with housing and health data is essential to understanding climate-sensitive exposure pathways. Evaluation of low-cost, climate-resilient housing interventions should explicitly include mental-health outcomes.

For policymakers and urban planners, indoor dampness and mold should be formally recognized as public-health risks within national housing standards, urban-development policies, and mental-health strategies. As climate change and rapid urbanization intensify humidity, flooding, and informal settlement growth across Africa, failure to address housing quality risks amplifying mental-health inequities. Embedding housing quality within climate

adaptation, urban resilience, and mental-health policy offers a cost-effective, preventive pathway to protect psychological well-being in vulnerable populations.

8. Limitations of the Evidence

Despite growing evidence linking residential dampness and mold exposure with adverse mental-health outcomes, several limitations should be considered when interpreting the current evidence base. First, the available literature is predominantly observational, including cross-sectional and cohort studies, which limits the ability to establish temporal and causal relationships between indoor dampness or mold exposure and mental-health outcomes (Gatto et al., 2024). Although associations with depression, anxiety, stress, and emotional symptoms have been reported, methodological heterogeneity and the relatively limited number of longitudinal studies restrict causal inference (Xian et al., 2025).

Second, substantial heterogeneity exists in the definition and assessment of dampness and mold exposure. Studies have variously relied on visible mold, reported dampness, water damage, condensation, building inspections, or microbiological measurements. Such differences make direct comparisons between studies difficult and may contribute to inconsistent estimates of exposure and health effects (Gatto et al., 2024; Mendell; Adams, 2022).

Third, accurate quantification of actual exposure to airborne fungal material, including spores and potentially relevant microbial constituents, remains challenging. Evidence indicates that commonly used microbiological measures, particularly airborne spore counts, do not necessarily provide a reliable or standardized representation of dampness or mold conditions in buildings. Spatial and temporal variability, differences among fungal species, and limitations in exposure assessment further complicate the establishment of quantitative exposure–response relationships (Mendell; Adams, 2022).

Fourth, socioeconomic and housing-related factors may act as important confounders or effect modifiers. Poverty, overcrowding, housing insecurity, poor ventilation, inadequate heating, structural deterioration, and limited access to housing repairs may simultaneously increase exposure to dampness and contribute independently to psychological distress. Consequently, distinguishing the specific contribution of mold exposure from the broader psychosocial effects of poor housing remains difficult (Gatto et al., 2024).

Fifth, the biological, psychological, and social pathways linking damp housing to mental health are highly interconnected, making it difficult to isolate the effects of individual mechanisms. Psychological distress may arise directly from housing conditions and perceived lack of control, indirectly through physical symptoms and sleep disruption, or through broader socioeconomic stressors. These overlapping pathways should therefore be considered when interpreting associations between indoor dampness and mental-health outcomes (Gatto et al., 2024).

Sixth, evidence from African and other low- and middle-income settings remains comparatively scarce. The recent state-of-the-science review identified a limited evidence base and emphasized the need for additional research capable of addressing contextual differences in housing conditions, environmental exposures, and mental-health outcomes (Gatto et al., 2024). This geographical imbalance limits the generalizability of findings derived predominantly from higher-income settings to tropical and resource-constrained environments (Coulburn; Miller, 2022).

Finally, the current evidence remains insufficient to establish that indoor mold exposure independently causes depression, anxiety, cognitive dysfunction, or other mental-health disorders. The available evidence supports an association between damp or mold-affected housing and poorer mental health, but causal interpretation remains constrained by observational study designs, exposure-measurement limitations, residual confounding, and heterogeneity across studies (Gatto et al., 2024). Future research should therefore prioritize longitudinal and intervention studies using standardized environmental exposure assessments and validated mental-health measures to clarify exposure–response relationships and causal pathways.

9. Conclusions

Invisible spores breed visible strain. Mold exposure bridges biological, psychological, and social determinants of health. In countries like Sierra Leone and Nigeria, where climate change intensifies humidity, indoor dampness could silently expand the population at risk of depression and fatigue. Recognizing and addressing mold exposure as a preventable risk factor offers a low-cost, high-impact opportunity to promote mental and

emotional well-being.

10. Authors' Contributions

Andrew Moseray: conceptualization; methodology; investigation; writing – original draft; writing – review & editing; project administration; submission of the manuscript and coordination of the revision process.
Abu-Bakarr Steven Kamara: investigation; data curation; writing – review & editing; validation.

11. Conflicts of Interest

No conflicts of interest.

12. Ethics Approval

Not applicable. This study is a narrative review and conceptual analysis of published literature and does not involve human participants, human data, or human tissue.

13. Artificial Intelligence Statement: Declaration of Generative AI and AI-Assisted Technologies in the Writing Process

The authors declare that generative AI and AI-assisted tools were used solely for English language and grammatical verification during the preparation of this manuscript. No AI tools were used to generate, modify, or create the scientific content, figures, images, schemes, or tables. All AI-assisted language corrections were reviewed, verified, and approved by the authors, who assume full responsibility for the accuracy, integrity, and originality of the manuscript. AI tools are not authors and do not assume any responsibility for the content of the manuscript.

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