Electronic Journal of General Medicine
2023, 20(6), em533
e-ISSN: 2516-3507
https://www.ejgm.co.uk/

MODESTUM

Review Article

OPEN ACCESS

The phenomenon of musical hallucinations: An updated review

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Citation: Al-Awad FA. The phenomenon of musical hallucinations: An updated review. Electron J Gen Med. 2023;20(6):em533. https://doi.org/10.29333/ejgm/13522

ARTICLE INFO

Received: 18 Mar. 2023

Accepted: 05 Jun. 2023

ABSTRACT

Introduction: Musical hallucinations (MHs) is a heterogeneous phenomenon. Multiple case reports and series have improved our understanding of this complex phenomenon. This systematic review aims to assess the available evidence regarding MHs.

Methods: PubMed and ProQuest databases were searched for articles published between 2005 and 2022. The keywords used for the search were "music," "musical," "hallucinations," and "hallucinosis."

Results: The search identified 421 articles; however, only 67 were selected. A total of 77 patients were selected from case reports and series. We identified 50 articles with single cases, four articles with two cases, four articles with three cases, and one article with six cases. Eight additional articles that provided information regarding the prevalence of MHs were included in the review.

Conclusions: MHs are common among older individuals, women, and hearing-impaired individuals. The etiologies include psychiatric, neurological, hearing impairments, and substances. Content of MHs is typically familiar songs/music. No randomized controlled studies are available for determining the treatment for MHs.

Keywords: hallucinations, music, review, auditory, musical hallucinations

INTRODUCTION

Hallucinations are involuntary perceptions that lack external stimuli but produce an experience similar to true perceptions [1]. Hallucinations can occur in nearly any sensory system, including the auditory, visual, tactile, olfactory, and gustatory systems. They are not necessarily due to chemical changes in the brain and are not generally caused by typical sensory pathways. Musical hallucinations (MHs) are a type of complex auditory hallucinations in which a person hears continuous or intermittent musical tones and melodies without external acoustic stimuli [2]. MHs continue to be an etiologically diverse phenomenon. Given rarity and complexity of this condition, our understanding of MHs has been primarily from case reports, case series, and small studies.

Berrios published a review of 46 case reports involving MHs in 1990. According to Berrios, deafness, ear pathology, advanced age, medications, and brain disease are the major contributors to the development and persistence of MHs. In 1992, a review examined 59 case reports, several of which overlapped those examined by Berrios [3]. However, the study [3] was the first to divide an entire group of cases into subgroups and analyze them separately. It described three groups with MHs, one with hearing loss, one with severe brain pathology, and one with a psychiatric condition. In 2004, another large review article investigated 43 case reports and analyzed the data of 132 individuals with MHs [4]. The cases were classified into five categories based on etiology: hypoacusis, psychiatric disorder, focal brain lesion, epilepsy, and intoxication. The cases comprised of 70.0% women, with a mean age of 61.5 years. In 2009, a review article was published that relied heavily on results and conclusions of previous reviews; but it did not follow a clear methodology [5].

After the literature search, we found that several case reports and series have been published since 2004. Therefore, we believe that it was time to conduct a systematic review of the literature between 2005 and 2022. The year 2005 was selected because the review included all previously published case reports [4]. The goal of this review is to offer practitioners a synthesis of information that will help them in their clinical practice. Prevalence, population characteristics, content, etiology, and successful therapies for MHs are also discussed.

METHODS

Study Selection

This review included case reports and series that investigated the phenomenon of MHs. The inclusion criteria of the case reports were, as follows:

(1) described the presence of MHs,
(2) described population characteristics,
(3) described the content of MHs,
(4) mentioned the most likely cause, and
(5) reported the interventions or treatments used.

The exclusion criteria were, as follows:

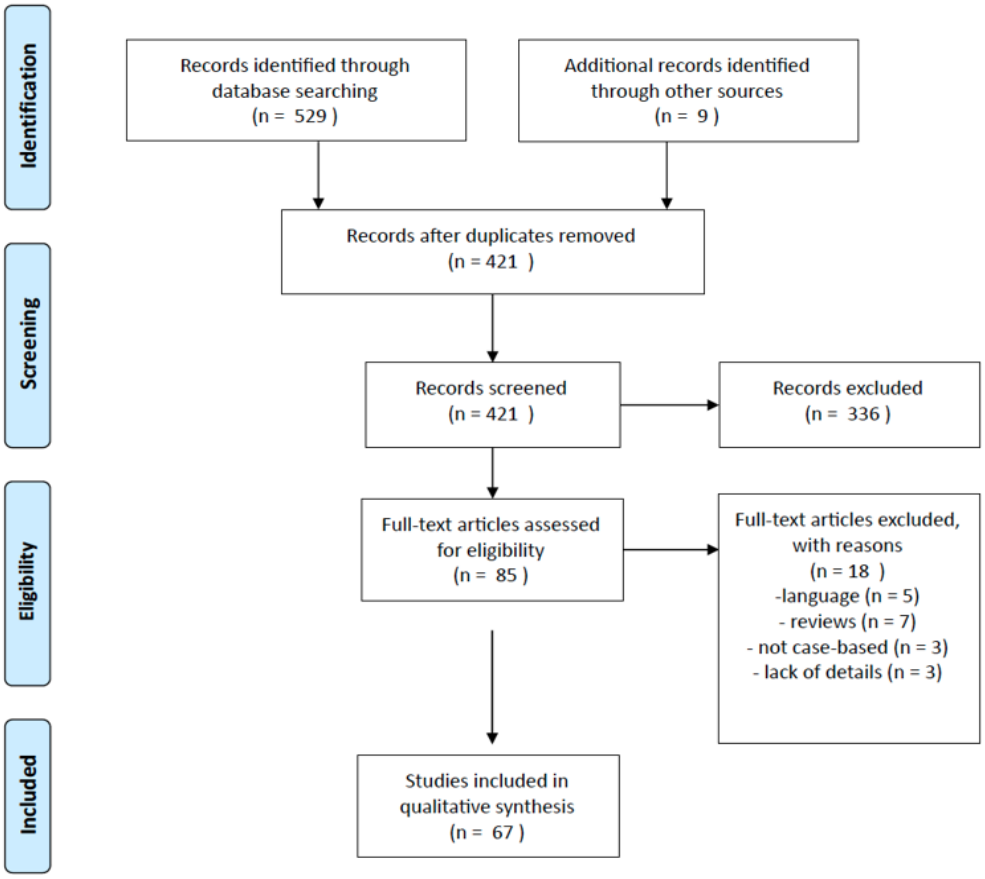

Figure 1. Search flow chart (Source: Author's own elaboration)

(1) the article was not in English,

(2) the article's full text was missing, and

(3) studies that included book reviews, editorials, commentaries, or letters.

Data Sources and Search Strategy

A systematic computerized search was finalized by the author on February 2, 2023, using two databases: PubMed and ProQuest. The keywords for the search strategy were "music," "musical," "hallucinations," and "hallucinosis." The identified studies were uploaded to EndNote and duplicate studies were excluded. Studies were included in a two-step process. First, the studies were screened based on their title and abstract; the second stage involved screening of the full text.

Data Extraction

The following relevant information were extracted:

(1) authors' name and date of publication,

(2) sample size,

(3) age (or age range) and sex,

(4) actual content of MHs,

(5) etiology, and

(6) treatment.

RESULTS

A total of 67 articles were included in this review (flowchart of the selection process is shown in **Figure 1**). A total of 77 patients were selected from the case reports and series. We identified 50 articles with single cases, four articles with two cases, four articles with three cases, and one article with six cases. Furthermore, eight articles out of 67 studied different groups to detect the epidemiology of MHs.

Table 1 provides a full description of each case report and series of published articles.

Table 1. Results of 77 subjects from case-reports & case-series experiencing MHs

R	SN	Gender & age	Content of musical hallucinations	Probable primary etiology	Co-diseases
[10]	1	Female, 97	Familiar, "Ave Maria", choral lyrics, & instrumental music	Left frontal lobe ischemic infarction	Hearing impairment
[11]	1	Female, 81	Soft music, songs with grandson's voice	Adverse childhood events	Anxiety
[12]	1	Female, 49	Organ notes, classical music, opera, & song "home of the brave"	Multiple etiologies (hearing impairment, depression, & drugs)	N/R
[13]	1	Male, 50	Mainstream popular music	Anti-IgLON5 disease	N/R
[14]	2	Case 1: Female, 60 Case 2: Male, 56	Classic music (familiar & unfamiliar) & marching band playing	Procedure: Electrical stimulation of anterior cingulate cortex for refractor chronic pain	Left thalamic stroke
[15]	1	Female, 61	Songs from 60's & 70's	Depression	N/R

Table 1 (Continued). Results of 77 subjects from case-reports & case-series experiencing MHs

R	SN	Gender & age	Content of musical hallucinations	Probable primary etiology	Co-diseases
[16]	1	Male, 71	Musical choral nature, folk songs, nursery rhymes, & well-known religious hymns	Lewy body dementia	Hearing impairment
[17]	1	Female, 59	"Cape Verde songs" & radio	Depression	N/R
[18]	1	Male, 77	N/R	Drug-induced (Amiodarone overdose)	N/R
[19]	1	Female, 78	Familiar church songs	Psychosis	Hearing impairment
[20]	1	Female, 22	Opera song & video game music	Drug-induced (paroxetine)	Depression & anxiety
[21]	1	Male, 67	Children songs	Right frontotemporal stroke	N/R
[22]	1	Female, 51	Songs with lyrics	Drug-induced (cefrazidime)	Hearing impairment
[23]	1	Male, 25	Instrumental & vocal components	Alcohol withdrawal	N/R
[24]	1	Male, 28	N/R	Anaplastic pleomorphic xanthoastrocytoma	N/R
[25]	1	Female, 67	Nursery rhythms	Traumatic brain injury	N/R
[26]	3	Case 1: Female, 87 Case 2: Female, 29 Case 3: Female, 86	Case 1: Popular singer Case 2: Familiar songs Case 3: Religious sermon	Case 1: Hearing impairment Case 2: Intracerebral hemorrhage Case 3: Schizophrenia	N/R
[27]	1	Male, 91	Popular songs & woman voice	Drug-induced (mirtazapine)	Depression
[28]	1	Female, 72	Familiar neapolitan, English, & French songs	Idiopathic	N/R
[29]	1	Female, 82	Religious chants & tones	Hearing impairment	N/R
[30]	2	Case 1: Female, 81 Case 2: Female, 75	Case 1: Familiar Japanese pop songs Case 2: Familiar foreign song	Case 1: Idiopathic Case 2: Depression	N/R
[31]	1	Female, 81	Childhood songs	Hearing impairment	N/R
[32]	1	Male, 78	Traditional songs & religious hymns	Hearing impairment	N/R
[33]	1	Female, 79	National anthem sung	Idiopathic	N/R
[34]	1	Female, 88	N/R	Hearing loss	Depression
[35]	1	Female, 62	Background jingle of favorite television program	Mesial temporal lobe epilepsy	N/R
[36]	1	Female, 61	Familiar songs, electronic organ sounds, & Korean pop songs	Hybrid cochlear implantation	N/R
[37]	1	Female, 71	Talkative voices & classical music	Multiple etiologies (OCD/hearing impairment)	N/R
[38]	1	Female, 74	Patriotic & children songs	Hearing impairment	N/R
[39]	2	Case 1: Female, 76 Case 2: Female, 78	Case 1: Hymns, lullabies, pop songs Case 2: Christmas carols	Case 1: Idiopathic Case 2: Idiopathic	N/R
[40]	1	Female, 85	Radio playing childhood songs	Thalamocortical auditory radiation infarct	Hearing impairment
[41]	3	Case 1: Male, ? Case2: Female, ? Case 3: Male, ?	Case 1: Gospel music Case 2: Hymns Case 3: N/R	Case 1: Psychotic depression Case 2: Hearing impairment Case 3: Schizophrenia	Case 1: N/R Case 2: Bipolar, dementia Case 3: N/R
[42]	1	Female, 72	Piano & radio songs	Pramipexole	Parkinson's disease
[43]	1	Female, 54	Popular religious music	Multiple sclerosis	N/R
[44]	1	male, 52	Operatic popular songs & classical music	Hearing impairment	Anxiety
[45]	6	4 females & 2 males Mean age=77	Familiar melodies and sounds	OCD	Hearing impairment
[46]	1	Female, 73	Japanese harp & nursery rhymes	Dementia	N/R
[47]	1	Female, 60	Popular songs	Hearing impairment	N/R
[48]	3	Case 1: Female, 79 Case 2: Female, 84 Case 3: Female, 85	Popular songs	Pontine lacunar lesions	N/R
[49]	1	Female, 44	Instrumental melody without lyrics	Pituitary macroadenoma	Hearing impairment
[50]	1	Female, 90	Traditional songs	Hearing impairment	N/R
[51]	1	Female, 75	Portuguese popular music	Hearing impairment	N/R
[52]	1	Female, 82	Popular italian songs	Right temporal ischemic stroke	N/R
[53]	1	Male, 70	Orchestral music	Hearing impairment	N/R
[54]	1	Female, 66	Familiar songs	Multiple etiologies (arachnoid hemorrhage, seizures, hearing impairment, & depression)	N/R
[55]	1	Female, 79	Patriotic song & favorite songs	Hearing impairment	Depression
[56]	1	Female, 52	Old familiar nursery rhythms	Psychogenic pain	N/R
[57]	1	Female, 57	Opera, piano, & child's voice	Drug-induced (steroids)	Cancer
[58]	1	Male, 34	Familiar songs	Insular glioma resection	N/R
[59]	1	Female, 77	National anthem, lullaby song, & popular songs	Drug-induced (amantadine)	Parkinson's disease
[60]	1	Female, 66	Rhythmic humming	Post-cochlear implantation	N/R
[61]	1	Male, 49	Melody & lyrics	Left temporal lobectomy	Epilepsy
[62]	1	Female, 82	Old familiar songs & melodies	Hearing impairment	N/R
[63]	1	Female, 75	Nursery song & familiar traditional songs	Idiopathic	N/R

Table 1 (Continued). Results of 77 subjects from case-reports & case-series experiencing MHs

R	SN	Gender & age	Content of musical hallucinations	Probable primary etiology	Co-diseases
[64]	3	Case 1: Female, 61 Case 2: Male, 78 Case 3: Female, 56	Case 1: Sad & love songs Case 2: Hymns & carols Case 3: N/R	Case 1: Depression & hearing impairment Case 2: Hearing impairment Case 3: Depression & OCD	N/R
[65]	1	Female, 45	Melodies & popular songs	Abdominal pain	N/R
[66]	1	Male, 83	Melodic & rhythmic motifs	Idiopathic & musician	N/R
[67]	1	Female, 93	Favorite childhood songs	Electroconvulsive therapy	Depression

Note. R: Reference; SN: Sample number; N/R: None reported; & OCD: Obsessive compulsive disorder

Table 2. Study populations for epidemiological papers

Reference	Recruited sample number	Population demographics	Number of patients with MHs (%)
[6]	225	General population	44
[8]	194	Audiology clinic	7 (3.6)
[9]	123	Psychiatric hospital	5 (3.9)
[68]	832	ENT-audiology clinics	52
[69]	16	Not specified	16
[70]	393	Mayo clinic medical records	393
[71]	24	Outpatient clinic	24
[72]	30	Psychiatric clinics	30

In **Table 2**, we present the findings of the eight epidemiological studies. The data analysis in our review was limited to published case reports and series. In the section "prevalence of musical hallucinations," the findings from the epidemiology articles were discussed; however, the cases were excluded from the data analysis because they lacked a detailed description of each patient.

We identified five distinct etiologies of MHs. Subsequently, we classified all cases into five distinct groups and attempted to identify their etiologies. After reading the entire article, we decided to allocate it to one of these categories. In patients with more than one probable etiology, the most likely etiology was selected, and the remaining etiologies were listed as co-diagnoses. Each case was assigned to one of these five categories: hearing impairment, neurological, psychiatric, substance-related disorder, or not otherwise classifiable (NOS) etiologies.

DISCUSSION

Prevalence of Musical Hallucinations

Due to its rarity, the prevalence of MHs in the general public is unclear and underreported. Existing data on prevalence are mostly drawn from small studies using diverse methodologies. Furthermore, all currently available studies reported prevalence rates among specific groups, primarily psychiatric, neurologic, and audiologic patients. A large online survey identified 270 individuals from European and non-European countries with hallucinatory experiences, including musical, imagery, earworms, and mixed hallucinations [6]. According to an online survey, 16.2% (44/270) of individuals experience MHs. In 2019, a cross-sectional study surveyed 832 individuals with hearing impairment and tinnitus who visited an ENT-audiology clinic [7]. It was found that 16.2% (n=134) of the individuals experienced auditory hallucinations in the past four weeks of which 35.0% were MHs. We found another study that interviewed 193 patients who were referred for audiometric testing [8]. Seven (3.6%) of the 194 patients with mild-to-severe hearing loss experienced MHs. The prevalence of MHs in patients in a psychiatric hopsital was investigated using a structured questionnaire and found that MHs were present in 3.9% (5/128) of the patients [9].

Demographic Data of all Cases

Women and older individuals were predominant in the cases (n=77). Women accounted for 76.3% of the cases (58/77), while men accounted for 23.7% (19/77). This sex percentage accounts for all etiologies. The average age of the 77 patients of all etiologies was 68.1 years (range, 22-97 years). We observed that 27.2% of the patients (n=21) had a co-diagnosis of epilepsy, Parkinson's disease, cancer, depression, hearing impairment, or left thalamic stroke. Such disorders may play a role in the etiology of MHs, resulting in confounding biases.

Etiology

MHs still represent a phenomenon with etiologic heterogeneity. No specific pathology explains the cause of MHs. Based on the literature, etiologies can be divided into five categories:

(1) neurologic,

(2) psychiatric,

(3) hearing impairment,

(4) substance-related, and

(5) not otherwise classifiable (NOC).

After grouping, the etiology "NOC" was predominant (24.6%, n=19), followed by psychiatric disorders (23.3%, n=18), hearing impairment (22%, n=17), neurologic disorders (16.8%, n=13), and substances-related (10.3%, n=8) etiologies.

Neurological disorder

A primary neurological diagnosis associated with MHs was found in 13 patients (16.8%). Women accounted for 92.3% (12/13) of the patients. The average age in this category was 69.9 years (range, 29-97 years). MHs have been linked to organic brain diseases; therefore, we concluded that no specific area of the brain was responsible for the onset of MHs and that they were a common neurodegenerative disease [16, 46]. According to the study in [70], Lewy body disease is the most common neurodegenerative condition, followed by Parkinson's disease and Parkinson's disease dementia. A

handful of case reports have identified a link between MHs and structural abnormalities of the brain.

We reviewed case reports that described etiologies such as left frontal lobe ischemic infarction, right frontotemporal stroke, traumatic brain injury, intracerebral hemorrhage, thalamocortical auditory radiation infarction, pontine lacunar lesions, pituitary macroadenoma, and right temporal ischemic stroke [10, 21, 25, 26, 40, 48, 49, 52]. MHs are common in patients having epilepsy or multiple sclerosis [35, 43]. 30.0% of the participants in the neurological group also experienced hearing loss. Cerebrovascular pathology was the most common neurological etiology in our review. According to the investigation in [70], the most prevalent structural lesion was a tumor. Lower-grade tumors (meningiomas, oligodendrogliomas, low-grade gliomas, and pilocytic astrocytomas) are more common in patients with MHs than in those with high-grade gliomas.

Psychiatric disorder

In the psychiatric group, the mean age of the patients was 69.7 years (range, 86-52 years), and 77.7% were women (n=14). Among them, 16.6% had documented hearing loss. Depression was the most prevalent psychiatric disorder, followed by obsessive-compulsive disorder. These findings are consistent with those of previous studies. A recently published study examined 16 older women and determined that MHs were substantially linked to mood disorders among them [69]. Psychogenic pain, adverse childhood experiences, adaptation impairment, borderline personality disorder, attention-deficit/hyperactivity disorder, and phase of life impairment are other psychiatric disorders linked to the onset of MHs [9, 11, 56]. A study examined 30 patients with MHs visiting psychiatric clinics and found that 13.0% and 20.0% of them had bilateral and unilateral hearing impairment, respectively [72]. Similarly, another study found a high incident of hearing loss among patients with psychiatric disorders having MHs [9].

Hearing impairment

17 patients (22.0%) were diagnosed with hearing impairment and all of them experienced MHs. Among the patients, 76.4% (13/17) were women and the mean age of the patients was 75.5 years (range, 52-90 years). Our results are consistent with those in [71]. Co-occurring psychiatric disorders, like depression, were present in 17.0% of patients. Case reports have frequently described the association of MHs with moderate or severe hearing impairment. While most reports describe MHs in conjunction with gradual onset of hearing loss, there have been reports regarding acute-onset of hearing loss.

A recent paper revealed that as the severity of hearing impairment increased, the percentage of those experiencing autiotory hallucinations increased dramatically, reaching 24.0% in the severely impaired category [7]. In a study involving 829 individuals with hearing loss, 16.2% (n=134) reported auditory hallucinations within the past four weeks. Voice (51.0%), music (36.0%), and ringing doorbells/telephones (24.0%) were the most common sounds experienced by the patients during auditory hallucinations.

Although there are few suggestions explaining the relationship between hearing loss and MHs, the actual process is unknown. The idea that people with hearing loss hallucinate similar to those experienced by the visually impaired (Charles Bonnet syndrome) has gained widespread recognition [73, 74]. Those who are visually impaired or have low vision may experience a phenomenon in which they see detailed images that have no physical counterparts. Deafferentation (the loss of sensory input from a body part due to damage to the peripheral sensory fibers) is the root cause of both these disorders [75, 76]. In the absence of an auditory input, the brain exhibits hypersensitivity analogous to denervation hypersensitivity, leading to the emergence of patterned sounds [44]. One study suggested that MHs and tinnitus share a common brain substrate, although their underlying mechanisms differ [77].

Substance-related

Eight patients experienced the onset of MHs within a short period of time after starting the drug or during withdrawal. The mean age in this category was 59 years (range, 22-91 years) and 62.0% (n=5) of the patients were women. This group had the youngest mean age of the five groups. Drug and substance toxicities can produce MHs. Drugs associated with the development of MHs in the case reports reviewed in our paper include amiodarone, paroxetine, cefrazidime, mirtazapine, pramipexole, steroids, and amantadine; MHs were also associated with alcohol withdrawal [18, 20, 22, 23, 27, 42, 57, 59]. Other drugs associated with MHs include stimulants, opiates, benzodiazepine, lisinopril, ramelteon, carbidopa/levodopa, and clarithromycin [70]. It is worth mentioning that it is often impossible to ascertain the relationship between drugs and MHs. Drug interactions, rather than a drug, have been proposed to lead to the onset of MHs.

Not otherwise classifiable

19 cases were identified and classified into this category. The mean age of patients in this category was 63 years (range, 28-93 years), and 68% (n=13) were women. This category includes

(1) cases that do not fit into any group described above,

(2) cases of idiopathic MHs, where no clear etiology is found to explain the pathogenesis of MHs, and

(3) cases, where multiple etiologies are described, and they all contribute equally to the onset of MHs.

Some case reports have revealed a complex interplay of probable otological, drug-induced, psychiatric, or neurological etiologies [12]. One case report identified an uncommon but increasingly recognized anti-IgLON5 disease accompanied by MHs [13], which demonstrates the diverse and ever-changing clinical phenotypes observed in autoimmune central nervous system diseases. Chronic pain, electrical stimulation of the anterior cingulate cortex for refractory chronic pain, anaplastic pleomorphic xanthoastrocytoma, hybrid cochlear implantation, insular glioma resection, left temporal lobectomy, abdominal pain, and electroconvulsive therapy were the other causes of MHs in the NOC group [14, 24, 28, 36, 58, 61, 65, 67].

Content of Musical Hallucinations

Unlike auditory hallucinations, people with MHs are aware and critical of this phenomenon, viewing it as strange. Most patients described hearing familiar songs that frequently included both vocal and musical instrument components. Religious songs, childhood songs, songs heard on the radio, folk music, and classical music have all been recognized as contents of MHs. Opera, songs from 1960s and 1970s, nursery rhymes, traditional songs, national anthem, patriotic songs,

Table 3. Treatment per etiology

Etiology	Treatment	n
Dementia	Clonazepam [46]	1
	Carbamazepine [46]	1
Ischemic stroke	Olanzapine [2, 52]	1
	Acetylcholinesterase inhibitor [80]	1
Traumatic brain injury	rTMS [79]	1
Intracerebral hemorrhage	Quetiapine [26]	1
Hearing impairment	**Pharmacological**	
	Carbamazepine [31, 47, 82]	3
	Escitalopram [45]	1
	Venlafaxine [12]	4
	Acetylcholinesterase inhibitor [12, 39, 50, 62, 80]	5
	Risperidone [32, 37]	1
	Gabapentin [83]	3
	Quetiapine [30, 41]	3
	Olanzapine [29, 32]	3
	Lamotrigine [54]	1
	Non-pharmacological	
	Wearing hearing aid [34, 38, 81, 84]	6
	Listening to radio [8, 64]	3
	Listening to music at bedtime [5]	1
	Using tinnitus mask [85]	1
Psychosis	Clozapine [19]	1
	Risperidone [26]	1
	Quetipaine [41]	1
	Olanzapine [41]	1
Post-cochlear implantation	Mirtazapine [60]	1
Multiple etiology	Lamotrigine [54]	1

piano, symphonic music, and video game background music were also mentioned.

It has been frequently observed that the patient's native language is the same as the language of the voice. Although bilateral perception of MHs is the most common, several case reports have demonstrated unilateral perception. Some people recognized that one instrument was more prominent than others. The vast majority of people described their perceptions as vivid, believing that music was being played in the room. MHs are frequently perceived as bothersome and intrusive, rather than enjoyable.

Workup and Diagnosis

Typically, no distinctive laboratory findings are associated with MHs. Electrolytes, complete blood counts, and liver enzymes are routine laboratory tests that typically yield inconclusive results. Nonetheless, neurological evaluation is warranted because of the wide variety of neurological factors that may play a role in the incidence of MHs. Neuropsychological tests can identify cognitive impairment. Those experiencing symptoms should undergo a thorough audiologic and otologic evaluation because of the possible link between hearing loss and MHs. Magnetic resonance imaging (MRI) and computed tomography (CT) scans have been utilized as a diagnostic and research tool in cases of MHs. Imaging investigations are helpful when trying to rule out structural abnormalities in the brain, such as tumors or ischemic abnormalities. Some investigators applied a multidisciplinary assessment model to the evaluation of patients experiencing MHs; this evaluation included

(1) otolaryngological assessment (including audiometry),

(2) neurological assessment (including electroencephalogram (EEG), cognitive assessment, and MRI), and

(3) psychiatric assessment [69].

Treatment

In our review, 23 articles discussed the administration of medications to patients with MHs. In total, 36 out of 77 individuals were treated with medications.

In **Table 3**, the treatments according to etiology are displayed, as well as the number of patients treated with each medication. The best results are typically observed when the main underlying cause, if found, is treated. Therefore, determining the etiology of MHs is important. When a substance or drug is the source of MHs, the first approach is to withdraw the drug or switch to a different drug. It should also be noted that treating MHs is not always necessary if they do not disturb the patient or have a substantial impact on their quality of life.

Non-pharmacological treatment typically consists of reassurance, explanations of the nature of MHs, coping skills, and behavioral changes (including cognitive behavioral therapy) [78]. In a few cases, MHs have been reported to diminish or disappear without treatment. Repetitive transcranial magnetic stimulation (rTMS) showed a positive response in a single medication-resistant patient [15, 79].

If no surgical intervention is necessary, pharmacological treatment is the best option [29]. To date, no randomized controlled trials (RCTs) have examined the pharmacologic treatment for MHs. The majority of the clinical data were from drug trials reported in case reports. The following classes of medications demonstrated favorable outcomes in the case studies reviewed (2005-2022): acetylcholinesterase inhibitors, antidepressants, antiepileptics, and antipsychotics. Several case reports suggest that acetylcholinesterase inhibitors (e.g., donepezil) may help patients with concurrent hearing loss [39, 44, 50, 62, 80]. Medications for hallucinations that develop as a result of mental illnesses should address this disorder. We should keep in mind that case reports may overstate the positive effects of a drug because negative effects are rarely reported. All medications used were off-label, and there was no defined scale for measuring the response to a specific treatment. A systematic review of the treatment of patients with MHs was conducted that examined all articles published between 1890 and 2015 [81]. They analyzed treatment results in relation to etiological factors in 276 individuals from case reports.

CONCLUSIONS

Despite an increasing number of case reports, less systematic research has been conducted on MHs. Familiarity with potential etiologies will assist clinicians in subclassifying MHs, as treating the etiology is important whenever it can be determined. However, the prognosis and course of MHs remain unknown. A prospective study would be beneficial to further delineate the relationship between MHs and deafness, as multiple hypotheses have been proposed to explain the pathophysiology. In randomized clinical trials, evidence of the clinical efficacy of medications has yet to be investigated. Standardized assessment and documented long-term follow-up of both the natural course of MHs and response to treatment

would be beneficial to the field of medicine. Until then, treatment of MHs rely heavily on clinical judgment and the few case reports published in the literature.

Limitations

This study had several limitations. First, data analysis of our review was limited to published case reports and series that provided full descriptions of each patient. Consequently, the sample size was relatively small (n=77), particularly when patients were divided into etiological subgroups. The study in [4] conducted a review of 132 patients, while the study in [3] evaluated 59 cases from the literature. Second, in a few case reports, the most likely etiology was not explicitly mentioned or identified by the original authors of the report, particularly when the patient had more than one plausible etiology. Consequently, the decision to assign a case to one of the five etiological categories was made solely at our own discretion. Third, in terms of therapeutic effects, our review included all drugs that resulted in notable improvement, without discriminating between those that resulted in total from those that resulted in partial improvement.

Funding: No funding source is reported for this study.

Ethical statement: The author stated that the study did not require any ethical approval since it is based on existing literature.

Declaration of interest: No conflict of interest is declared by the author.

Data sharing statement: Data supporting the findings and conclusions are available upon request from the corresponding author.

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