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ABOUT THE JOURNAL

„Annals of Nursing" is the official journal of the Medika College of Vocational Studies in Healthcare, Belgrade Serbia. It is a quarterly international open access peer-reviewed journal that covers all aspects of nursing in hospitals, families, and communities. The papers published in "Annals of Nursing" are freely available to all internet users for non-commercial use. The focus of the journal is on the role of nurses in the promotion of health and the quality of life, prevention of illness, care of disabled and ill people and all suffering individuals and rehabilitation after illness.

EDITORIAL BOARD

LETTER OF THE EDITOR-IN-CHIEF

Dear Readers,

In the third issue of Annals of Nursing you will have the opportunity to read four reviews and one original article.

In his review article about noise and Alzheimer's disease author Goran Belojević, Editor-in-Chief of Annals of Nursing, presents up-to-date scientific information on the possible relationship between acoustic stress and the most common type of dementia. This research is justified with mutual global growth of noise exposure and of the burden of Alzheimer's disease. From this paper we learn that possible mediating factors in this relationship may be sleep disturbance, excitotoxicity, oxidative stress injury in the auditory cortex and hippocampus, and systemic inflammation. The possible pathophysiological mechanisms that connect noise exposure with brain cell death, loss of synapses and amyloid beta deposition and tau hyperphosphorylation include hearing loss, activation of HPA axis and NMDA receptor activation.

Authors Stojanovic et al. have prepared an interesting review about social isolation and loneliness (SI&L) among the elderly as a very important public health problem. Besides a very high prevalence of SI&L in elderly, ranging from 10% to 28 % of utmost importance is the relationship of SI&L with dementia, depression, coronary heart disease and stroke. The authors inform the readers about the significant factors related to SI&L: female gender, unmarried

status, older age, poor income, lower level of education, living alone, low quality of social relationships, poor self-assessment of health and poor functional status.

Authors Veličković and Živojinović are bringing a comprehensive review about the types of medical waste (MW), regulatory acts, risks of exposure to MW, management procedures and control techniques. This is a very important issue for nurses/technicians for their practice in hospitals as they are in frequent contact with MW. The readers learn from this article about emerging technology in MW management which involves loading, shredding, heating, sterilization, cooling, draining, vacuum and unloading and the whole process is enclosed in a compact system with no intermediate handling of MW. This system is expected to be widely used in hospitals for on-site MW management.

Authors Vlaisavljević et al. have prepared an interesting original article about nursing interventions for patients with cardiac pacemakers (CP). This interview study was performed in a Belgrade clinic among patients and nurses/technicians. After a very comprehensive introduction about the anatomy of the heart impulse transmission, principle of CP operation, indications for a CP, complications after CP implantation, the authors present that 80% of the patients are satisfied with the work of nurses/technicians in their health care and vice versa nurses/technicians are mostly satisfied with their patients' and colleagues' cooperation (80% and 95% , respectively). The authors conclude that nurses/technicians largely contribute to successful health care of patients with CP.

Professor Lubica Argalasova, our dear member of the Editorial Board, presents an excellent and up-to-date review of secondhand smoke (SHS) and its effects on maternal health, child health and intervention possibilities. From this article we learn that SHS may have negative

effects on pregnancy outcome in terms of low birth weight, preterm birth, respiratory distress, and stillbirth. SHS is related to depression particularly in women. Concerning SHS - child health relationship prof. Argalasova informs us that SHS may be related to respiratory disease, and sudden infant death syndrome, and conduct disorder, attention-deficit/hyperactivity disorder, and additional cognitive impairments. The author presents alternative tobacco products, like water pipes, heated tobacco, e-cigarettes, chewing tobacco and hookah and points that these deserve scientific attention due to the possibility of their harmful effect on health. It is important for nurses/technicians to follow the initiatives of tobacco smoke-free working places, public places, and public transport.

In the coming issues of Annals of Nursing we will do our best to bring a wide range of topics that are relevant for the practice of nurses/technicians.

Kind regards,

Goran Belojević

Editor-in-Chief

Annals of Nursing

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Review Article

NOISE AND ALZHEIMER'S DISEASE

Goran Belojević

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Abstract

Alzheimer's disease (AD) is the most common form of degenerative dementia and the seventh leading cause of death. Numerous influencing factors for AD have been investigated: aging, female gender, genetics, unhealthy diet, hearing loss, unhealthy lifestyle, physical inactivity, insufficient sleep, head injury, depression, hypertension, and environmental factors (air pollution, aluminum, silicon, selenium, pesticides, lack of sunbathing, electric and magnetic fields). Recent animal and human studies point to a possible relationship between noise exposure and AD. The aim of this narrative review is to present basic pathological concepts of this relationship. Possible mediating factors that explain the influence of noise on AD are sleep disturbance, excitotoxicity, oxidative stress injury in the auditory cortex and hippocampus, and systemic inflammation. Studies on animals point to cognitive dysfunctions related to noise exposure: anxiety-like behavior, impaired learning and memory, increased glutamate levels in the hippocampus and reduced expression of N-methyl-D-aspartic acid receptor 2B. Neuropathological changes in animals

exposed to noise include necrosis and apoptosis of hippocampal cells, accumulation of amyloid β, tau hyperphosphorylation and peroxidative damage in the hypothalamus and the auditory cortex, and the elevated expression of proinflammatory cytokines and microglial activation in the auditory cortex and hippocampus. Human brain scan studies have pointed to the positive relationship between traffic noise exposure and white matter volume in the body of the corpus callosum at the level of the auditory cortex. In conclusion, there is a biological plausibility of the noise-AD relationship, and noise countermeasures may be regarded as the prevention of AD.

Keywords: noise, Alzheimer's disease, pathology

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Introduction

Alzheimer's disease (AD), named after the German psychiatrist and pathologist Alois Alzheimer[1], is the most common form of degenerative dementia, contributing to 60-80% of all cases of dementia[2]. Currently, about 50 million people in the world suffer from Alzheimer's disease, with nearly 10 million new cases every year. It is the seventh leading cause of death, and the major cause of disability and dependency among the elderly, with a financial burden of more than one trillion US dollars annually[3,4]. By the year 2050, the global prevalence of AD is expected to be around 115 million[5].

AD is pathologically characterized by shrinkage of the cerebral cortex and hippocampus, enlarged ventricles, neurofibrillary tangles (NFT) of the hyperphosphorylated tau protein[6], amyloid plaques due to the accumulation of amyloid beta (Aβ)[7] and loss of neuronal synapses in the brain[8].

The characteristic symptoms of AD are loss of memory and concentration, mood swings and depression, disorientation of place and time, self-neglect, difficulties in speaking, reading, and writing, and in the late stage, disability to recognize the closest family and difficulties in swallowing and urination[9].

The cause of AD is still unknown. There are two major AD hypotheses: cholinergic hypothesis focuses on the reduction of acetyl-choline synthesis from choline and acetyl coenzyme A in the cholinergic neurons due to the decreased activity of enzyme choline acetyltransferase[10]; amyloid hypothesis explains neurodegeneration in AD with the neurotoxic effect of Aβ accumulation in the brain[11].

There are numerous risk factors for AD which can be classified into the following groups: genetic factors, age and gender, head injuries, infections, cardiovascular disease, lifestyle, obesity, diabetes mellitus, and environmental factors. About 70% of AD cases are related to mutations in the dominant genes[12]. Aging is the most potent risk factor for AD, especially 65 years and older[13]. AD affects women more often than men (65% vs. 35%, respectively)[14]. Head or brain injuries raise the chance for the onset of AD after 5 years by about 20%[15]. Chronic bacterial and viral infections of the central nervous system may lead to the accumulation of (Aβ) and NFT [16]. Cardiovascular diseases may cause the loss of brain tissue (stroke) or hypoxia due to reduced circulation in the brain (heart failure, atherosclerosis, hypertension)[17].

Concerning lifestyle, aerobic physical exercise[18], mental activity like playing chess or reading or crossword puzzles[19], leisure activities[20], continuing education[21], avoidance or cessation of smoking[21], adequate sleep[19], and techniques to decrease stress[22] may reduce the risk of AD. Obesity[23] and diabetes[24] are risk factors for AD due to neuroinflammation, oxidative stress, and amyloid-beta accumulation. Malnutrition[25] as well as saturated fatty acids and high calorie intake[26] increase the risk of AD, while fish and supplementation with polyphenols, antioxidants, and vitamins, may lower the risk of AD[26]. Concerning environmental factors exposure to air pollutants including low ozone, carbon monoxide, particulate matter, nitrogen oxide, sulfur oxide and lead is related to oxidative stress, neuroinflammation, and neurodegeneration and tau phosphorylation, and Aβ accumulation in the brain cortex[27]. Finally, exposure to some metals is related to AD. Accumulation of aluminum in the brain may lead to phosphorylation of tau proteins[28], while exposure to lead and cadmium is related to aggregation of Aβ plaques in the brain[29].

According to the World Health Organization (WHO) burden of disease analysis it is estimated that around 1,6 million disability-adjusted life-years are lost each year due to environmental noise exposure in the European Union Member States and other Western European countries. Around 45.000 of lost DALYs are related to cognitive impairment of children[30]. Recent animal and human studies point to a possible role of noise exposure as a new risk factor for AD, permanently testing the hypothesis on the noise-AD relationship[31,32,33,34]. The aim of this review is to present evidence for the noise-AD relationship and to discuss basic pathological concepts underlying this connection.

Materials and Methods

Full papers in the English language were searched in the PubMed database from inception to the 1st of April 2023, using keywords "noise" and "cognition" and "learning" and "memory" and "dementia" and "Alzheimer's disease". The inclusion factors were original studies or reviews about chronic noise exposure and cognitive functions in animals or humans. The results are classified into three sections: studies on animals, studies on humans, and pathological concepts.

Results

Studies on Animals

Cognitive effects of noise. Exposure to noise during the gestational period led to a significant increase in corticosterone levels and stimulation of hypothalamic-pituitary- adrenal axis (HPA) in mice and post-partum detrimental effects on spatial learning and memory function[35]. Prenatal noise exposure also had a negative cognitive effect on the mice offspring in terms of affected spatial learning[36]. Beside offspring's cognitive impairment, a reduced expression of glucocorticoid and mineralocorticoid receptors in the hippocampus was found after exposure to noise during the last trimester of pregnancy in rats[37]. There was a difference in cognitive effects of short-term exposure (6 to 10 days) and long-term exposure (26-40 days) to combined traffic noise of 70 dB (A). The former had a stimulating effect on learning and memory of mice related to increased level of glutamate in hippocampus, while the latter showed a cognitive decline and lowered glutamate concentration[38]. Loud noise (95-97 dB, 2h/day,30 days) had detrimental effects on spatial memory and associative memory of rats. These behavioral changes were followed by the imbalance in the oxidative status in the cerrebelum

and hippocampus. Reactive oxygen species were increased in the beginning of exposure and decreased after 30 days. On the other hand, antioxidant activity of hyppocampal catalase was increased throughout 30 days of noise exposure, while the activity of sodium dismutase decreased after the first exposure to noise, but it was raised after 30 days[39]. After the cessation of noise exposure (80 dB or 100 dB for 4 h per day, for 30 days) the impaired learning and memory functions as well as the decreased levels of hippocampal neurotransmitters dopamine, norepinephrine and 5-hydroxytryptamine in rats recover within 30-40 days[40].

Neuropathological effects of noise. Typical neuropathological changes in rodents exposed to chronic noise include persisting overproduction of Aβ and neuroinflammation related to elevated tumor necrosis factor-α[41], tau phosphorylation concomitant with the formation of NFT in the hippocampus and the prefrontal cortex, typical for AD brain[42], reduction of proliferating cells in the hippocampal formation related to elevated corticosterone serum levels[43], oxidative damage in the auditory cortex, and hippocampus[44], and the inferior colliculus - the principal midbrain nucleus of the auditory pathway. The hippocampus seems to be more vulnerable to chronic noise than auditory cortex, with more intensive peroxidation and tau phosphorylation[45]. Prenatal noise exposure leads to the development of amyloid beta (Aβ) plaques in offspring, particularly in females[46]. Exposure of adult rats to noise 100 dBA/4h per day for 30 days caused a significant decrease of dendritic count in hippocampus and medial prefrontal cortex[47]. Another important biochemical effect of exposure of rats to chronic noise (100 dB, 4 h/d×30d) is the decrease of the expression of N-methyl-D-aspartic acid receptor 2B, resulting in tau hyperphosphorylation and neural apoptosis in hippocampus[48]. Hyperactivity of HPA in mice after exposure to noise for 30 days led to structural changes in brain in terms of reduction of brain volume, medial prefrontal cortex area, cortical thickness, hippocampal volume, and amygdala area[49]. Both acute noise exposure (one day) and subacute noise exposure (between postnatal days 15 and 30) of 95-97 dB SPL, 2h daily, caused histological changes in

the hippocampal region CA3 of the rats in terms of the increased number of pyknotic cells and a total number of cells, indicating cell death due to necrosis and apoptosis[50].

Studies on Humans

Cognitive effects of noise. Occupational noise of 68 dB had detrimental effects on participants' attention and short-term memory in terms of a higher number of errors and a longer reaction time compared to control acoustical conditions (45 dB). Participants also experienced higher levels of discomfort, stress, and annoyance[51]. The moderators of cognitive effects of experimental exposure to noise (slower psychomotor speed, reduced working memory and episodic memory, and more cautious decision-making) include subjective noise sensitivity, paranoia, sleep quality and cognitive disorganization[52]. After experimental nocturnal combined exposure to aircraft, rail, and road traffic noise pooled noise exposure data showed detrimental effects on performance in terms of prolonged reaction time compared to quiet conditions. There were no significant differences in the effects on performance regarding noise sources, but the level of noise annoyance was highest after exposure to aircraft noise[53]. When the performance effects of laboratory and field nocturnal aircraft noise were compared during 9 consecutive nights, a dose-response increased reaction time in the psychomotor vigilance task was found, and more pronounced in the field compared to laboratory noise exposure (0.3 ms/dB LAeq vs. 0.13 ms/ dB LAeq)[54]. Subjective noise sensitivity is an important moderator in the cognitive effects of noise. Persons with high noise sensitivity show worse mental performance results under noisy conditions and a higher noise annoyance level compared to subjects with low noise sensitivity[55,56]. Neurotic persons and introverts show enhanced arousal levels and worse results in cognitive tasks under noisy conditions compared to extroverts and more stable personalities[57,58] . Exposure of elderly women to residential road

traffic noise ≥50 dB Lden had the effect of impaired total cognition and the constructional praxis domain measured by Consortium to Establish a Registry on Alzheimer's Disease (CERAD-Plus) Neuropsychological Assessment Battery, compared to <50 dB Lden conditions[59]. Concerning the effect of noise on children's cognition, aircraft noise seems to have some detrimental effect on reading comprehension and long-term and short-term memory, while having no substantial effect on attention and executive functioning[60]. Some occupations are under a relatively higher risk of noise induced cognitive effects. The fighter jet pilots show significantly lower accuracy in delayed verbal and visual memory tests in comparison to the controls. These cognitive deficits are followed by neuron dysfunction of the hippocampus, in terms of decreased gray matter volumes and regional homogeneity compared to controls[61]. However, there are also published results of the absence of significant relationship between environmental noise and the risk of dementia[62].

Noise and degenerative dementia. A recent meta-analysis based on 11 studies revealed the relative risk for AD of 1.18 (95% CI: 1.14–1.23) per 25 dB increase in noise exposure level [63]. In a 13-year cohort study in Denmark, both road traffic noise and railway noise were associated with a higher risk of Alzheimer's disease, with hazard ratios of 1.16 (95% confidence interval 1.11 to 1.22) for road L_{den}max ≥65 dB compared with <45 dB, 1.27 (1.22 to 1.34) for road L_{den}min ≥55 dB compared with <40 dB, 1.16 (1.10 to 1.23) for railway L_{den}max ≥60 dB compared with <40 dB, and 1.24 (1.17 to 1.30) for railway L_{den}min ≥50 dB compared with <40 dB[64] .The odds ratio (95%CI) for overall mild cognitive impairment and amnestic mild cognitive impairment was 1.40 (1.03, 1.91) and 1.53 (1.05, 2.24), respectively, with a 10 A-weighted decibel [dB(A)] increase in LDEN of traffic noise. The authors point to a possible synergistic effect of noise and air pollution with $PM_{2,5}$ on cognitive impairments[65]. In another population-based study the odds (95% CI) of prevalent mild cognitive impairment and Alzheimer's disease were 1.36 (1.15 - 1.62) and 1.29 (1.08 - 1.55), respectively with each

increment of 10 A-weighted decibels (dBA)[66]. However, there are also published results of the absence of significant relationship between environmental noise exposure and cognition and cortical thickness in brain regions known to be affected by Alzheimer's disease[67]. In a 15-year cohort study in Sweden no significant association was found between exposure to residential noise levels (Leq. 24 h) > 55 dB and dementia risk (HR 0.95; CI: 0.57, 1.57)[68]. In a study performed in Madrid during a nine-year period there was no significant relationship between daily and night noise levels (dBA) and emergency Alzheimer's disease hospital admissions[69]. In a population-based cohort study on 2,2 million people aged 20-50 years in Canada the adjusted hazard ratio (HR) of incident dementia was 1·07 for people living less than 50 m from a major traffic road (95% CI 1·06-1·08), 1·04 (1·02-1·05) for 50-100 m, 1·02 (1·01-1·03) for 101-200 m, and 1·00 (0·99-1·01) for 201-300 m versus further than 300 m (p for trend=0·0349). The limitation of this study was that no distinction was made between degenerative and vascular dementias[70]. In another similar population-based study no significant relationship was found either between estimated noise level or proximity to major roads and the incidence of Alzheimer's disease[71]. The brain scans of cognitively unimpaired individuals aged 45 to 74 at increased risk of AD showed a positive correlation between traffic noise levels and white matter volume in the body of the corpus callosum at the level of the auditory cortex[72]. The limitations of the so far epidemiological studies on noise and dementia include the absence of distinction between degenerative and vascular dementia, uncontrolled hearing status, noise exposure bias (noise maps, proximity to busy roads, and traffic flow).

Pathological concepts of noise-AD relationship

An interaction between noise exposure and gene mutations may lead to neuropathological changes characteristic of AD. When APP/PS1 mice were exposed to chronic noise significant

increases in the hippocampal phosphorylated Tau and overproduction of Aβ were found, together with the activation of VDAC1 that is involved in the mitochondria-mediated apoptosis[73]. After senescence-accelerated mice prone 8 (SAMP8) were exposed to white noise of 98 dB SPL for 30 consecutive days a real-time PCR was used to determine the differential gene expression. Compared to controls, there were 21 protein-coding transcripts that were differentially expressed under chronic noise, of which 8 were related to AD. Noise significantly increased the expression of genes Arc, Egr1, Egr2, Fos, Nauk1, and Per2. and these genetic changes were followed by the hippocampal Aβ accumulation and increased hyperphosphorylation of Tau[74]. Neuropathological changes in the brain of SAMP8 after noise exposure were followed by the decrease of gut microbiome diversity, change in its composition, and detrimental effects on the microbiome-gut-brain axis in terms of, disrupted epithelial barrier function in the intestine and blood-brain-barrier[75].

Hearing loss has been related to cognitive impairments both in experimental and epidemiological studies. In animal models, hearing loss and Aβ administration to the rats' brain showed worse cognitive function and lower levels of synaptic proteins in the hippocampus compared to rats with only Aβ administration, only hearing loss, and without hearing loss or Aβ administration[76]. In a population based 3-year cohort study patients newly diagnosed with hearing loss were compared with a group with no hearing loss, matched by sex, age, residence and SES. Patients with HL had a significant risk of dementia compared to the controls, and the highest risk was for the group aged 45-64 years (HR, 1.40; 95% CI, 1.12-1.75)[77]. Hearing loss has detrimental effects on the quality of life, contacts, and physical activity, and is related to depression and dementia[78]. A 4-year cohort study on older adults (mean age 65 years) showed that loneliness and social isolation are significantly and negatively related to cognition[79]. People with hearing loss use a much larger cognitive load while listening compared to people with normal hearing. The consequence is a reduction of available cognitive

resources, and the acceleration of cognitive decline[80]. Noise exposure has toxic effects on the hippocampus consisting of oxidative stress and excitotoxicity, and consequently disruption of neurogenesis, synaptic loss, Aβ overproduction and tau hyperphosphorylation. Neuroinflammation that is often associated with NIHL[81] is also a contributing factor to the initiation and advancement of Alzheimer's disease[82]. After exposure of rats to noise levels of 100dB for two hours daily during 15- and 30-days cognitive impairments were associated with elevated levels of TNF-α, IL-6, IL-1α, and IFN-γ in both hippocampus and plasma. Pathologic cellular changes included an increase in the number of pyknotic and apoptotic neurons[83]. Experiments on rodents show that in addition to hearing loss other factors are needed to trigger the process of degenerative dementia, such as aging, APOE genotype, or microvascular disease[84].

Experiments with prenatal noise exposure of mice showed that anxiety-like behavior and reduced learning and memory performance were associated with the activation of the HPA axis in terms of elevated plasma cortisol levels[85]. The hippocampus and prefrontal cortex of the brain are particularly sensitive to the detrimental effect of the hyperactive HPA axis, showing reduced neurogenesis, dendritic atrophy, disordered synaptic plasticity, and functional impairment[86]. In the experiments on rats chronic noise caused the progressive overproduction of corticosterone and upregulated corticotropin-releasing factor (CRF) and CRFR1 mRNA and protein, followed by tau phosphorylation in the prefrontal cortex[87].

The pathway of the possible effect of chronic noise exposure on tau hyperphosphorylation may also be explained by the disorders in glutamate (Glu)-NMDAR signaling. Dizocilpine, also known as MK-801, which is a pore blocker of the N-Methyl-D-aspartate (NMDA) receptor, a glutamate receptor, decreased tau hyperphosphorylation in rats' hippocampus and PFC after noise exposure[88]. Chronic noise decreased the expression of B2 NMDA receptors, causing

glutamate upregulation and tau hyperphosphorylation, and neural apoptosis in the hippocampus of rats[89]. Dendrites are particularly vulnerable to oxidative stress, energy deficits, and excitotoxic NMDA receptor activity[90].

Oxidative stress is another possible explanation for the noise-AD relationship. Tau protein may be hyperphosphorylated by protein kinases[91] that are activated with reactive oxygen species (ROS) formed during noise exposure[92]. ROS also may play a role in the disruption of lipid homeostasis and amyloid precursor protein formation[93].

Noise-induced psychological stress is characterized by the activation of the sympathetic adrenal medullary axis. Elevated levels of dopamine and norepinephrine in the rat's cerebellum and striatum have been found after exposure to noise of 100 dB for 4 h/day for 15 days. Monoamine oxidase metabolizes the excess amounts of dopamine to free radicals such as superoxide radical and hydrogen peroxide which mediate changes in the morphology of the cerebellar Purkinje cells[94]. The brain regions that are particularly sensitive to stress induced cellular changes like neuronal loss, dendritic retraction, or glial changes include the hypothalamus, hippocampus, amygdala, nucleus accumbent, prefrontal and orbitofrontal.

These possible pathways of the effects of noise on cognition and dementia are shown in Figure 1.

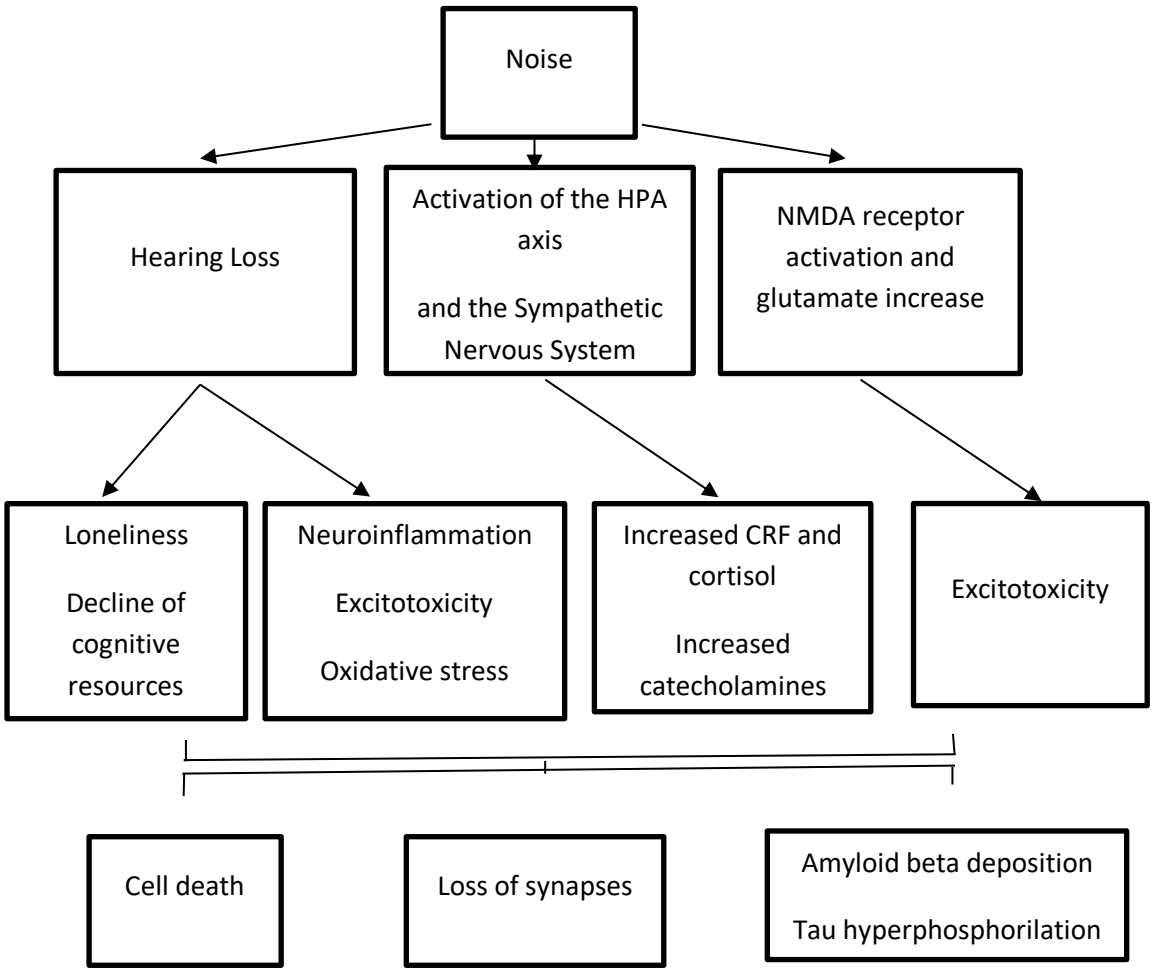

Figure 1. Noise and Alzheimer-s disease – possible pathophysiological mechanisms

Conclusion

There is a biological plausibilty for the association between noise exposure and Alzheimer's disease. The pathways of this relationship include both hearing loss and no-hearing loss- related mechanisms like social isolation, a decline of cognitive resources, excitotoxicity, neuroinflammation, oxidative stress and psychological stress. Given the great public health importance of the mutual global growth of noise exposure and of the burden of Alzheimer's

disease, continuing research of this relationship is justified. In further research, it would be interesting to investigate the effectiveness of hearing aids in reducing cognitive decline in the elderly. More studies on the noise-AD relationship are needed in industrial settings where much higher noise levels are recorded, intervention studies may be carried out and better control of confounding factors is possible compared to residential settings.

Conflict of Interest

The author declares no conflict of interest.

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Review Article

SOCIAL ISOLATION AND LONELINESS AMONG THE ELDERLY

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Abstract

Old age is a physiological process that leads to numerous changes in the body and mental and social functioning. Social isolation and loneliness (SI&L), which represent both objective and subjective experiences of social disconnection, have emerged as two key constructs that affect people's health and are particularly relevant to the physical and mental health and longevity of the elderly. The aim of this review is to assess the frequency of SI&L among the elderly, factors related to SI&L, as well as their impact on the quality of life and health of the elderly and the role of nurses/technicians in their healthcare. We performed a search of PubMed database using keywords “loneliness”, “social isolation” and “elderly”. The prevalence of SI&L among the elderly is from 10% to 28%. Significant factors related to SI&L are female gender, unmarried status, older age, poor income, lower level of education, living alone, low quality of social relationships, poor self-assessment of health and poor functional status. Increased frequencies

of dementia, depression, coronary heart disease and stroke have been found among old people with SI&L Health education interventions carried out by nurses/technicians should promote the social inclusion of the elderly.

Keywords: loneliness, social isolation, elderly

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Introduction

Aging represents one of the biggest social, economic and health challenges of the 21st century, especially in Europe, the continent with the largest share of people over 65 in the total population. Active aging is the process of optimizing opportunities for health, safety, and social participation of older people with the aim of improving the quality of life of older people[1]. The goal of active aging is to improve the quantity and quality of life. Changes in old age are diverse, highly specific, and indivisible. All aspects of health change in old age, especially mental health, which is affected by various factors. According to the pioneer of social gerontology, R. Havighurst, there are six tasks that a person at that age must face[2].

- adaptation to decline in physical strength and health,

- adaptation to retirement and reduced income,

- adjusting to the death of a spouse,

- establishing a clear connection with one's own age group,

- adopting and adapting social roles in a flexible way,

- establishing a satisfactory physical environment for life.

The positive features of old age are also described, such as creativity and achievements, and successful aging, which first and foremost implies a positive self-concept with a realistic assessment of abilities. Although in everyday life we categorize them as health climate, social or economic climate, in the elderly population, more than in any other group, these age climates are intertwined and connected to such an extent that they essentially represent one inseparable whole.

Individual variations in the elderly are far more pronounced than at any other age. Two old people of the same age can differ significantly from each other in terms of health, mental, social, and physical and all other aspects of functioning. The terms "healthy" and "pathological" aging were therefore introduced to denote one (albeit insufficiently adequate) surrogate to describe this fact[1].

Modern tendencies of a holistic approach to health care and people's health still encounter obstacles created by prejudices about old people. The term "ageism" was first used by Butler in 1969 to express in one word systematic stereotyping and discrimination based on age[3]. Ageism is a widespread phenomenon that includes all structures of society and all age groups. After racism and sexism, Butler believes ageism is the cruelest prejudice.

Social isolation and loneliness (SI &L)

Loneliness is the subjective state of feeling that a person is alone, separated from others, and is conceptualized as an imbalance between desired social contacts and actual social contacts[4]. Social isolation represents an objective lack of meaningful and sustainable communication. Social isolation is the objective absence or lack of contact and interaction between a person and a social network[2]. Loneliness is therefore the way in which people perceive and experience the lack of interaction (social isolation). On the other hand, social isolation is a condition in which an individual lacks a sense of social belonging, lacks engagement with others, has a minimal number of social contacts, and lacks fulfillment and quality relationships[5].

Loneliness is a disturbing and universal human experience that is experienced by all people to a greater or lesser extent during life and is manifested by social isolation[4]. There are many definitions of SI & L. Some authors define loneliness as an unpleasant feeling, and painful longing for another person[6]. Loneliness is also defined as a disturbing emotional state of lack of intimate and close relationships with a partner, family, or friends. Several authors define loneliness as a mismatch between the interpersonal relationships a person has and the ones they would like to have[5].

According to some authors, there are two types of loneliness, namely emotional loneliness, and social loneliness. Emotional loneliness or the loneliness of emotional isolation, is a discrepancy between the desired and available interpersonal relationships, the absence or loss of close emotional ties such as partner, friendship, parent-child relationships, feeling of emptiness.

Social loneliness or loneliness of social isolation is characterized by a lack of integration, absence of social network - rare contacts or lack of participation[7].

Some other authors, on the other hand, indicate four types of loneliness:

- Physical loneliness – spatial and temporal distance from others and is mostly emotionally neutral.

- Loneliness – the feeling of rejection from the people with whom the individual would like to be.

- Isolation - which cannot be changed because it is a consequence of political, religious, legal, and other obstacles.

- Desired loneliness[8]

The aim of this review is to assess the frequency of SI&L among the elderly, factors related to SI&L, as well as their impact on the quality of life of the elderly and the role of nurses/technicians in their health care.

Materials and Methods

For this research, a systematic analysis of studies about SI&L was applied. We performed a search of PubMed database using keywords “loneliness”, “social isolation” and “elderly”.

Results and Discussion

Epidemiology of SI & L

Social isolation and loneliness show a trend of increasing frequency in the geriatric population. In 2011, 24% of self-reported community-dwelling older adults (65+) in the National Health and Aging Trends Study in the United States, approximately 7.7 million people, were characterized as socially isolated, including 1.3 million (4%) who were characterized as severely socially isolated according to the study by Cudjoe et al.[9]. Su et al. [10] found that the combined prevalence of SI&L at the global level in 2021, in the era of the coronavirus pandemic was 28.6%. Research by Huang et al.[11] showed that the prevalence of loneliness and social isolation among older adults in Taiwan was 10.5%.

In 2018, the AARP Foundation commissioned the National Academies of Sciences Engineering, and Medicine to establish a commission to research and produce a report on SI&L among people aged over 50 years[12]. Older adults are at increased risk of SI&L, especially those over 80. A meta-analysis showed that 40–50% of those who were aged 80 years and more expressed marked loneliness[13]. Researches on gender differences in SI&L have shown that men are lonelier than women and that those who are not in a partner or marriage relationship are lonelier[14].

Using data from the nationally representative US Health and Retirement Study, Perissinotto et al found that 43% of Americans over the age of 60 reported feeling lonely[15]. Among this sample, 13% reported that these symptoms occur "often." The AARP Foundation conducted a

survey and found that 35% of adults over the age of 45 in the United States reported feeling lonely. Older adults who are socially isolated are typically among the oldest, unmarried, male, have low education, and low income[9].

Factors related to SI&L in old age

Health policymaking and health systems need to proactively address the growing demand for appropriate psychological services among older adults. Social resources are essential to prevent social isolation and mitigate health risks, including poor quality of life, physical disability, and cognitive impairment. Many have studied social isolation as a risk factor; however, few have investigated the sociodemographic factors that may predispose older adults to this problem. Understanding the factors that may alter an older person's risk of social isolation may help develop policies or interventions that prevent or address this important problem. Cohen-Mansfield et al.[16] determined that significant factors of SI&L are female sex, unmarried status, older age, poor income, lower level of education, single life, low quality of social relationships, poor self-assessment of health and poor functional status. Psychological attributes associated with SI&L include poor mental health, low self-efficacy beliefs, negative life events, and cognitive deficits. Personal characteristics (age, gender, education, income, functional impairment, chronic diseases) were significantly associated with both social isolation and loneliness in the study by Menec et al.[17]. Wagner et al.[18] found that higher neuroticism and lower extraversion and openness are related to SI&L in elderly. On the other hand, the study by von Soest et al.[19] highlighted female sex, disability, absence of a spouse/common-law partner, widowhood, and little contact with friends as significant risk factors for loneliness. Slightly different findings were also shown by the research of Wright et al.[20] that is, old, divorced men are often lonelier than old widows.

The mental health of the elderly population is affected by various factors that, in cooperation with each other, can accelerate the development of mental disorders in the third age. The fact is, however, that psychological disorders in old age do not have to be directly related to the physiological processes of aging[15]. Compared to younger adults, older adults score lower on most affective and anxiety disorders[1]. Older people attribute feelings of depression to old age and therefore do not seek help or mention symptoms. In a longitudinal study of the world population older than 70 years, psychiatric morbidity increases from 24% at the age of 75 years to 31% at the age of 79 years[3]. Clinical research has recognized many risk factors for SI&L, but from the beginning it has been emphasized that the risk can be two-way[1]. Cross-sectional and longitudinal studies provide evidence of reciprocal effects of SI&L on anxiety and depression disorders that may worsen over time[21]. Cross-sectional studies have often found associations of loneliness or lower measures of relationship quality and support with high depression. Some depressed older adults experience broad deficits in social connectedness, including high loneliness, low social support, and fewer social ties[12].

Personality traits such as low extraversion and high neuroticism have been shown to increase the risk of loneliness among older adults with depression and anxiety[18]. Other individual factors include living alone, inadequate family relationships or support, caregiver burden, disruptive life events (such as moving to another residence), bereavement (perhaps the most significant immediate cause of SI&L), illness and ill health, and functional disability (which limits a person's ability to socialize), sensory deprivation (such as hearing loss) and retirement. Risk factors for SI&L in older adults also include cognitive deficits and dementia[18]. Social factors, such as the lack of public transport, can also contribute to SI&L. Aging in place can be both a risk and a protective factor for SI&L A private home can provide a sense of comfort and security, but it also poses a danger if functional disabilities disrupt normal household routines.

Rural residents are more likely to face challenges seeking services at home. Older women report greater emotional suffering and depression than men. Some studies show that in men, depression is associated more with stress, chronic diseases and reduced physical activities[18]. Gender differences do not currently have clear explanations and are usually attributed to biological, genetic, and acquired differences. Elderly people are more susceptible to the influence of risky physical factors: hunger, war, high temperatures, higher mortality. More than 80% of people over the age of 70 have at least one chronic disease, many have multiple chronic conditions[22].

Functional abilities are needed to perform daily activities (feeding, dressing, maintaining hygiene, cleaning the apartment, shopping, etc.) and represent a universal factor that is significantly related to mental states. Weaker functional abilities are a strong predictor of further weakening of functional abilities[4]. With greater difficulties in physical abilities, depressive symptoms also increase, and life satisfaction decreases. About 60% of people over the age of 65 do not have to limit their more important activities for health reasons. After 85 years, that percentage drops to 50%[23]. Emotions are mostly related to dissatisfaction and grow to anger and rage. Some studies confirm the association of hostility with poorer health (cardiovascular diseases) and shorter life expectancy. Hostility has also been shown to be a risk factor for suicide in old age in combination with anxiety and depression[15]. Social support can be the very source of useful information that increases coping. It is a mechanism that can reduce functional disability, a depressive symptom, is associated with lower mortality and is one of the significant predictors of life satisfaction[4]. Elderly persons of higher socioeconomic status have better psychological health than those of lower socioeconomic status. In a study of the elderly, a negative correlation was found between the decline in physical activities of daily life and the possession of "excess" money[7]. Most often, the elderly use informal forms of health

care that they organize together with their families. Some data show that 84% of the elderly have informal care, 18% of people older than 75 years help another person with health problems, 11% said they helped with health care[5]. According to recent theories and research in gerontology, late years and near death are accompanied by reduced physical and social engagement, spending time with a small number of close friends, as well as increased interest in spiritual and transcendental values[6].

Consequences of SI&L in the elderly

Social isolation is associated with a significantly increased risk of premature mortality from all causes based on research studies spanning over 40 years. The increase in mortality can be attributed to the risk of social isolation, competing with the influence of physical risk factors such as obesity and smoking[24]. Although SI&L often occur simultaneously, their combined and interactive effects on health outcomes have rarely been studied. A comprehensive meta-analysis of 148 prospective studies measured both SI&L as well as a combined, multiple measure of social connectedness[25].

A model of possible direct and indirect mechanisms by which social ties affect disease morbidity and mortality is shown in Figure 1. Morbidity and mortality of elderly are related to lifestyle, social interactions, psychological factors, biomarkers, and medical adherence.

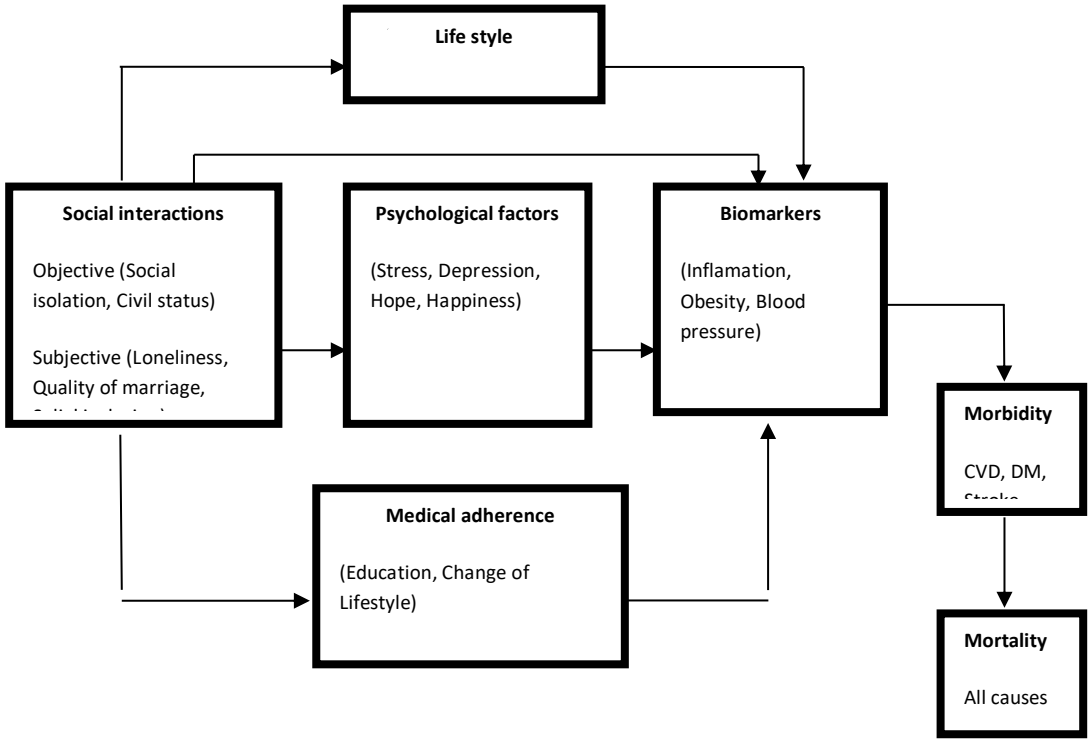

Figure 1. A simplified model of possible direct and indirect mechanisms by which social ties affect disease morbidity and mortality (Holt-Lunstad et. al 2015[25])

In numerous longitudinal studies, SI&L have been found to increase the risk of developing coronary artery disease and stroke independently of traditional risk factors for cardiovascular disease[14]. Low social support was associated with increased rates of hospital readmission and mortality after myocardial infarction. In patients with heart failure, a higher perception of loneliness was associated with more frequent visits to the outpatient clinic and emergency room and hospital admissions[26]. A study of over 11,000 older adults in the US found that less frequent social contact was associated with higher rates of depression over a 2-year period[27]. As expected, depression is the most relevant cause of suicide, but SI&L were found to be independent factors contributing to an increased risk of suicide attempts. In a study of over 60,000 older adults, increased loneliness was found among the primary motives for self-injury[2].

In addition, earlier social anxiety was a predictor of future loneliness, with a bidirectional relationship[28]. In an Irish Longitudinal Study of Aging of over 5,000 participants, the relationship between loneliness and generalized anxiety was bidirectional, but stronger when loneliness was the source[1]. In a meta-analysis conducted in 2015, the authors found that an increased risk of dementia was associated with a high level of loneliness, ie. infrequent social contacts and participation in groups at a low level[29]. These social factors increased the risk of dementia by approximately 50%. Similarly, in a later meta-analysis, researchers found that living alone, having a limited social network, or low frequency of social contact increased the risk of dementia[12]. In addition, among cognitively normal adults, increased perceptions of loneliness are associated with higher levels of brain amyloid and regional accumulation of tau protein, linking loneliness to the pathological changes of early Alzheimer's disease[12]. In one study, social isolation had a significant, independent, and negative effect on health-related quality of life (a narrower approach to quality of life that includes perceived physical and mental health)[30]. A secondary analysis of prospective follow-up data from the English Longitudinal Study of Aging (ELSA)[14] found that SI&L were associated with an increased risk of cardiovascular disease. In a cohort study, Golaszewski et al. [31], showed that SI&L were independently associated with a modestly higher risk of cardiovascular disease among US postmenopausal women, and women with both social isolation and loneliness had a higher risk of cardiovascular disease than those with only one exposure. An Australian study[32] showed that SI&L was associated with higher risk factors for atherosclerosis.

Prevention of social isolation and loneliness in the elderly

Support for active aging at the level of the social community is provided by support in the areas of policy, which is implemented in several important areas: legislation; pension system; health and social protection; special education and rehabilitation and other significant areas; by developing institutional and non-institutional forms of care for the elderly. In addition to promoting healthy lifestyles, healthcare workers provide health care services in home and institutional conditions (homes for the elderly, gerontological centers, centers for the elderly, institutions for extended care of the elderly[33] with measures to improve health within health centers. The development of gerontological and geriatric services that actively support the health status of the elderly with preventive, therapeutic and rehabilitation programs, as well as the continuous education of health workers in the field of education about the health of the elderly support the families of the elderly**.** Nutrition is a basic life activity/habit. For good health, independence in functioning, and resistance of the organism, diet and nutritional status are of great importance. The recommended type of diet can influence the risk of disease occurrence as well as the occurrence and development of chronic diseases that lead to accelerated and pathological aging. Physical activity, mobility is a prerequisite for health, and according to Weber, it is of particular importance for active aging and the quality of life of the elderly[6]. Physical activity requires the interaction of the nervous, musculoskeletal, cardiovascular, respiratory, and other systems. Thus, loss of sight significantly limits the movement of an elderly person, respiratory and cardiovascular diseases lead to limitations in endurance and significantly disable the elderly person in movement and performing life activities, etc.

Studies have shown that the presence of social connections is associated with important positive health effects, including reduced mortality, better immune function, and lower levels of cardiovascular disease progression. Social isolation exists in varying degrees of severity; studies have assessed threshold effects that explain variance in vulnerability and outcomes. These different levels of social integration have produced mixed results with some studies finding different effects of degree of social isolation on mortality. Assessments of social isolation among older populations should consider both subjective and objective dimensions, as well as family and friendship social networks. Social isolation from friends is an important but understudied issue that has significant consequences for the mental health of older adults. Research by Taylor et al.[34] found that in the elderly, subjective social isolation from family and friends was associated with more depressive symptoms, and subjective social isolation from friends only was associated with higher levels of psychological distress. The longitudinal association between the experience of loneliness and a greater likelihood of suffering from a mild cognitive disorder or generalized anxiety disorder is bidirectional, but stronger with loneliness as an origin, while the relationship between social isolation and a greater likelihood of subsequent development of these disorders, as well as between loneliness and the subsequent worsening of social integration are unidirectional[1]. Domènech-Abella et al. [35] showed that loneliness and depression are related, especially in the elderly. A study by Santini et al.[36] found that higher levels of spousal support, less spousal strain, and better integration into social networks were protective factors against depressive symptoms in men. Social support from friends and children was protective against depressive symptoms in both sexes.

Health professionals working in the primary care sector, such as home care nurses, may be able to identify SI&L among older people at home. Identifying and addressing SI&L must become an important issue in home care. Tomstad et al.[37] showed that home care nurses identified SI&L

among older people as a complex and sensitive phenomenon that activated conflicting thoughts, feelings, and solutions in a system where the loneliness of older people was generally not considered a need requiring care. SI&L among older people presented a challenge for nurses in terms of conveying feelings of SI&L of older people and meeting their social needs. Organizational structures were perceived as the main obstacles to meeting these needs.

The feeling of loneliness of older people stimulated the nurses' reflections on the purpose of their role as nurses. It is important to address SI&L among older people living at home and incorporate it into home care to meet their needs for social contact. Home care managers must pay attention to nurses' experiences, promote nurses' acquisition of knowledge about this type of SI&L, and learn how to meet the needs of the elderly. A special focus should be placed on communicating with lonely and socially isolated older people to address their feelings of SI&L from society. Sya'diyah et al. [38] showed that nurses tend to prevent the occurrence of SI&L in the elderly through caring and empathic care.

Person-centered care constructs such as fulfilled preferences, sense of control, and life satisfaction may contribute to loneliness among nursing home residents, but these relationships have not been extensively investigated. The relationship between fulfilled preferences and life satisfaction used by nurses in the care of elderly persons with SI&L indicates an important connection between person-centered care, especially the fulfillment of preferences for personal care and recreation, and the social-affective needs of long-term care residents[33]. Manjunath et al. [39] found that group and individual interventions against social isolation/loneliness were of the highest quality because SI&L experienced by older adults decreased after the intervention, and this effect persisted in follow-up studies. A study by Quan et al.[40] showed that in 87% of

the elderly with SI&L psychological interventions lead to an improvement in the health status of the elderly.

Conclusion

Based on a systematic review of studies by other researchers to assess the frequency of SI&L in the elderly as well as their impact on the quality of life of the elderly, we have concluded that the prevalence of loneliness and social isolation in the elderly is from 10% (Taiwan) to 28% (USA). Many studies have shown that being single, female gender, low education and low income are independently associated with loneliness and social isolation. Psychological attributes associated with SI&L include poor mental health, low self-efficacy beliefs, negative life events, and cognitive deficits. SI&L in elderly are related with dementia, depression, coronary heart disease and stroke, independently of traditional cardiovascular risk factors. Psychological interventions and communication skills interventions significantly reduce the SI&L problem in the elderly.

Conflict of Interest

The authors declare no conflict of interest.

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Review Article

MEDICAL WASTE MANAGEMENT: TREATMENT, RECYCLING AND DISPOSAL OPTIONS

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Abstract

Medical waste (MW) is all waste generated in healthcare institutions during the provision of healthcare services, conducting scientific research and experiments in the field of medicine, regardless of its composition and origin, i.e.. a heterogeneous mixture of classic municipal waste and hazardous MW. Medical systems including hospitals, clinical centers, and places where diagnosis and treatment are conducted generate waste that are highly hazardous and put people under risk of fatal diseases. In general, MW does not take up much of the environmental pollution, but its specific characteristics are potentially among the most dangerous types of waste. Inadequate care can affect the health of the medical workers, the population, and the surrounding areas in which the waste is stored, but also lead to outbreaks of global infection and poisoning. However, extra caution is required to avoid the risk of injury, cross-contamination, and infection; thus, healthcare workers and individuals responsible for waste management must follow the mandatory safety procedures. In this review, a classification of the various types and categories of MW and its treatment methods are discussed. Since MW

can be contaminated and hazardous, it must be managed and processed using complex steps and procedures. The meaning of MW, the risks of exposure, MW management regulatory acts, MW management procedures and control techniques are presented.

Keywords: medical waste, individual health; legislation

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Introduction

Medical waste (MW) is limited to infectious, hazardous, and any other waste that are generated from health care institutions, such as hospitals, clinics, dental offices, and medical laboratories[1]. The management of MW has been of major concern due to potentially high risks to human health and the environment.

The World Health Organization (WHO) defines MW as any waste or by-products from hospitals and health care facilities for humans and animals used for diagnosis, treatment, or immunization, e.g., used syringes, needles, metal sharps, dressings, blood samples, body parts, pharmaceutical, chemical, radioactive materials, and devices[1]. Generally, countries with high revenue generate up to 0.5 kg/hospital bed of hazardous medical waste[2]. The health care sector's waste extensively impacts the environment and public health, proving very costly.

Hassan et al., 2008 report a survey on Bangladesh hospitals that generate a total of 5562 kg/day of waste, of which about 77.4% are non-hazardous and about 22.6% are hazardous. The average waste generation rate for the surveyed hospital is 1.9 kg/bed/day or 0.5 kg/patient/day. In Bangladesh, proper medical waste management is a new phenomenon and

government of Bangladesh is trying to develop a new and modern approach to deal with the MW properly[2].

The manufacturing and discarding of medical and health care sector waste leads to increased levels of greenhouse gases emissions and pollution[3]. The types of plastics that are mainly used to make operating room tools and equipment are polyvinylchloride, polyethylene, polyropylene, polyurethane, and co-polymers. The first three types of plastics can and are being recycled. In general, most of the operating room's waste can be considered non-hazardous because it is generated even before the patient arrives and is not contaminated or infected[4]. The use of hand gloves made of latex or plastic for protection by ordinary people and workers in various sectors after the pandemic led to an increase in the amount of disposed of gloves. In addition, gloves also contribute to pollution of the environment when disposed of improperly because they are made of unrecyclable and undegradable materials[5,6]. A study highlighted that 15% of the total global carbon budget is attributed to the greenhouse gases emissions resulting from the life cycle of plastics[7]. Therefore, poor management and disposal of plastics threaten the ability of the global community to meet carbon emissions targets and combat climate change [8].

A vast variety of pollutants are released from a MW incinerator, including fly ashes as particulate matter, carbon monoxide, heavy metals, e.g., arsenic, chromium, nickel, cadmium, copper, lead, etc., acid gases such as sulfur dioxide, nitrogen oxides, and hydrogen chloride, organic compounds such as carbon tetrachloride, benzene, toluene, xylenes, and polycyclic aromatic hydrocarbons. In addition, leachable organic compounds form bottom residues and ashes containing heavy metals and dioxins. In addition, there is the carbon footprint of transportation, autoclave decontamination, thermal treatment (i.e., low and high temperature

incineration at 850 Cº and 1000 C°, respectively), plus the carbon emissions produced during recycling[9,10,11].

The specific objectives of this review are as follows: (i) to classify and categorize the different types of MW generated from healthcare facilities, (ii) to outline the steps and processes involved in the disposal, segregation, and treatment of MW, (iii) to compare the practices for management and treatment of MW in clinical centers of Serbia and define the least deleterious methods and, thus, help decision-makers in the health sector and industry to make better choices, and, finally, to demonstrate the impact and consequences of the COVID-19 outbreak on the amounts of MW".

The objective of this paper is to inform readers about the MW management regulatory acts, definition of medical waste, risks of exposure, MW management procedures and control techniques.

Medical Waste -Definitions

WHO has classified MW into different types: a) Infectious: material containing pathogens in concentrations high enough to cause diseases on exposure. This includes waste from surgery, lab cultures, used dressings, and others. b) Sharps: disposable needles, syringes, blades, broken glasses. c) Pathological: tissues, organs, body parts, human flesh, blood, and body fluids. d) Pharmaceuticals: drugs and chemicals that are returned, spilled, expired, or contaminated. e) Chemical: waste resulting from diagnosis, or cleaning material. f) Radioactive: waste contaminated with radioactive substances used in diagnosis and treatment of diseases. g)

Pressurized containers including gas cylinders; and h) Substances with high heavy metal content: broken mercury thermometers, blood pressure gauges. Infectious, pathological and sharps are the most dominant types of MW [12].

The definition of MW excludes waste containing microbiological cultures used in food processing, urine, saliva, and nasal secretions unless they contain blood. Like any household and office, medical facilities also generate general waste such as paper and plastic that are not dangerous to human beings[13]. Medical waste such as sharps (*i.e.*, needles, syringes, scalpels, etc.) can endanger humans in a non-infectious way. Regardless of its quantity and where it is generated, MW has serious sometimes fatal effects on exposure. Medical staff, janitors, medical center visitors and patients are exposed to the risk of infection and diseases because of exposure. Thus, MW hazards and risks exist not only for the waste generators and operators, but also for the general community including children who play near disposal areas. The possible exposure pathways include direct contact, airborne transmission, contaminated water sources and the environment in general. The Medical Waste Tracking Act (MWTA, 1988) is the first act to regulate MW[14]. It was implemented after life-threatening incidents occurred due to the lack of proper MW disposal systems. One example of such an incident was in June 1987 when 12 children in Indianapolis, Indiana, played with vials they found in a dumpster outside a medical office. The vials were filled with blood, and two of them were infected with AIDS. After MW was found washing up on several East Coast beaches, USEPA (US Environ-mental Protection Agency) prompted US Congress to enact the MWTA in 1988[15]. The Act required EPA to create a two-year MW demonstration program.

Classification of Medical Waste

According to estimates by the WHO, 15 to 20% of MW can be classified as hazardous materials due to their infectivity, toxicity, and, sometimes, radioactivity[16,17]. MW refers directly or indirectly to infectious, toxic, or otherwise hazardous waste (HMW), illustrated in Figure 1 and described with examples in Table 1. Medical institutions generate this type of waste during medical or preventative care and related activities, specifically infectious, pathological, damaging, pharmaceutical, and chemical waste[18]. On the other hand, non-hazardous medical waste (NHMW) includes all different regular non-infectious fractions of waste, such as municipal solid waste. HMW is usually contaminated with pathogens. Therefore, it can cause a wide range of infections and diseases in the case of misuse or poor handling and discarding. Adding to that, it can cause environmental contamination in the case of poor management, causing pollution to land, water, plants, animals, and air, leading to the spread of diseases.

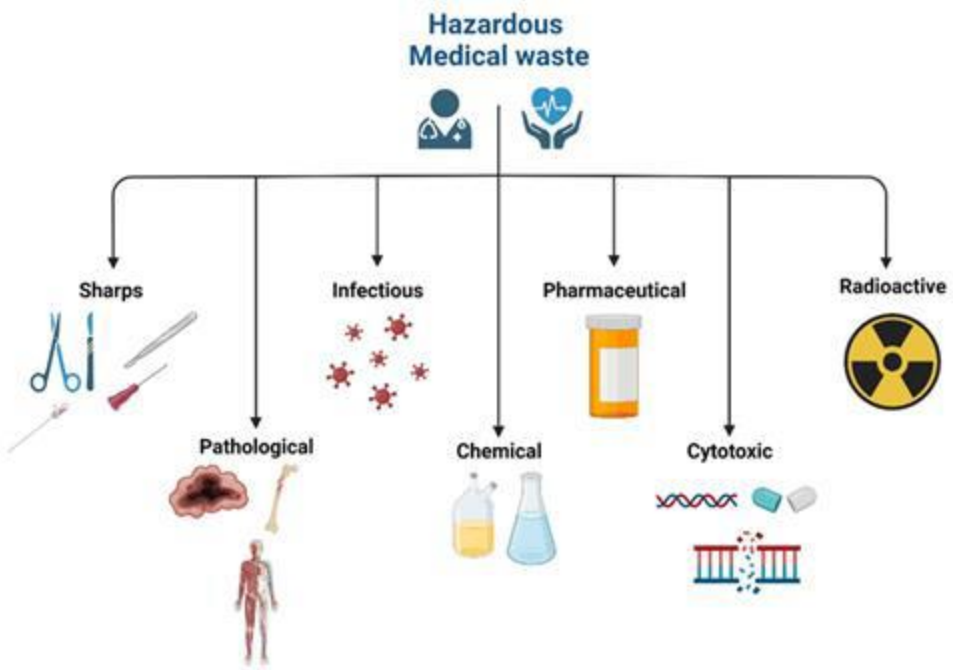

Figure 1. Different types of hazardous medical waste

Table 1. Healthcare waste categorization according to WHO and the EU [19,20].

Category	Examples	WHO	EU	Source
	Sharps	Sharps	Sharps	Hospitals, clinics, laboratories, blood banks,nursing homes, veterinary clinics and labs
	Organic matter, including. body parts and blood	Pathological	Human tissue, body parts, organs, and blood preserves and bags	Hospitals, clinics, laboratories, mortuary and autopsy facilities, veterinary clinics and labs
Hazardous	Waste with restrictions in collection and disposal due to infectivity	Infectious	Human and Animal Infectious	Hospitals, clinics, and laboratories

	Waste with no restrictions or special requirements for collection and disposal due to infectivity (e.g., plasters, casts, dressings, bed sheets, disposable clothing, etc.)	Infectious	Infectious	Hospitals, clinics, and laboratories
	Dangerous chemical materials and substances	Chemical	Chemical	Hospitals, clinics, and laboratories
	Other chemicals	Chemical	Chemical/ Unused hazardous medicines	Hospitals, clinics, and laboratories
	Cytotoxic and cytostatic medicines	Cytotoxic	Discarded unused medicines	Hospitals and laboratories
Nonhazardous	Other chemicals (non-hazardous)	Pharmaceutical	Unused nonhazardous medicines	Hospitals, clinics, and laboratories
	Dental clinics (care centers) amalgam waste	Amalgam (tooth filling) waste from dental clinics/centers	Amalgam waste from dental clinics/centers	Dental care centers and clinics

Medical Waste Management

MW management is a series of steps where the MW generated is handled from the generation point until it can be disposed of safely.

Waste Generation

The critical aspect of this step is the amount of waste produced and how it is handled to prevent hazards to the personnel in contact with it. The waste generated from medical institutions can be minimized to reduce waste accumulation. The minimization can be approached from different directions, such as reduction in waste at source, recycling, and stock management.

Waste Segregation

Segregation is useful since it prevents the contamination of non-hazardous waste by the hazardous waste and making the whole waste stream hazardous. Thus, this method will reduce the toxicity and the volume of the waste stream. Moreover, segregation makes it easier to transport the waste. Waste is segregated depending on the quantity, composition, and the disposal method of the waste stream. Segregation is mainly achieved by separating different categories of MW in different color bins or bags specified for each category. The sharp objects should always be separated at the source[21]. The segregation is carried out by medical staff, which requires training to safely dispose of waste to avoid infections[17]. If a mistake occurs while segregating waste, it should not be corrected to prevent the contamination of the other waste [21]. MW should be stored safely to avoid unauthorized human contact, which can cause infections [17].

Separating Different Categories of Medical Waste

In medical centers, infectious and pathological waste, and sharps are placed in different containers. The containers are labeled as “biohazard”, closed, watertight and of uniform color for each type of MW throughout the medical center. The size of the containers depends on the volume of waste generated and the containers used are easy to handle and transport. For used needles specially designed containers are recommended.

The system for segregation, packaging, labeling, and marking involves separating the MW into categories, as described. The packaging is done in colored bags[22]. For example, yellow plastic bags are used for infectious MW that is meant to be disposed of by means of incineration or deep burial in landfill. However, if they are to be treated by autoclave or microwave, they are placed in red plastic bags or containers. In steam autoclaving, the waste is decontaminated by the effects of the saturated steam at elevated temperatures and high pressure. This method is not applicable for pathological, chemotherapy and radioactive waste.

Hazardous waste packaged in either blue or white transparent bags is usually treated by autoclave, microwave, chemical treatment, and shredding, or by landfilling. As for labeling and marking, W is known to have the bio-hazard symbol. Both the packaging and labeling are adopted worldwide[22].

Waste Collection and Transportation

The frequency of MW collection should be as high as once per day to avoid the accumulation of waste, which can spread infections. In addition, the personnel responsible for collection should be equipped with safety gear to prevent contaminations and infections [21]. The waste is collected from the health care entity and transported using secondary transportation to the treatment facility for disposal, recycling, and treatment processes. Treatment facilities are either located within the health care facility or off-site in a separate location [17].

Disinfection

In order to reduce the toxicity of some MW, chemical disinfectants (*i.e.* chlorine dioxide, sodium hypochlorite, or per acetic acid) are sometimes used. For solid waste, disinfection is effective if only waste materials are shredded. In some cases, the disinfectants themselves are

hazardous, thus it is not recommended for treating pharmaceutical, chemical and some types of infectious waste.

Waste Treatment

MW treatment is a process carried out before the disposal of MW to limit the hazardous effects of this type of waste on the environment and health. The lack of proper treatment can have several impacts, as follows [23]:

Poisoning from toxic elements,

Bacterial and fungal infections,

Release of toxins into the atmosphere,

Leaching to the soil and underlying aquifers,

Bioaccumulation,

Leaving a footprint on the environment,

Destruction of habitats.

In the production phase of any medical equipment, the impact of these types of equipment must be considered by performing a life cycle analysis and practicing proper treatment techniques. However, the methods and techniques for treatment have minimal impact in terms of carbon emissions released into the ambient air. For example, a

single intravitreal injection causes the release of 0.05 kg CO_2 during the disposal phase [24].

Incineration

Incineration is the most widely practiced treatment method due to its applicability to treating all waste types. The incineration process is carried out in furnaces operated at temperatures of 800–1200 Cº. The high temperatures kill the pathogens, destroy 90% of organics, and change the waste characteristics such as weight, volume, and shape [25].

This process is governed by several parameters such as [26].

- Mixing of waste,

- Moisture content,

- Amount of waste in the furnace,

- Temperature,

- Residence time,

- Maintenance and repair.

Incineration produces fly ash and emissions such as dioxins, furans, and mercury. Dioxins and furans are considered carcinogenic, have a half-life ranging from 7 to 11 years, and are persistent footprints on the environment. Dioxin emissions can be reduced if the complete combustion of waste is achieved[25]. The dioxins emitted can also be treated using selective non-catalytic reduction. This technology depends on the production of free nitrogen via the reaction between nitric oxide and ammonia, and this gas is of high effectiveness and low cost[24]. Fly ash

is a solid residue from incineration, rich in heavy metals. Fly ash can be recycled but must undergo chemical pre-treatment first by using ethylene diamine tetra acetic acid disodium or sodium sulfide, which removes the heavy metals from the fly ash[25]. Approximately 3 kg of CO_2 is produced from burning 1 kg of clinical waste, therefore, incinerating MW contributes to global warming by releasing significant amounts of greenhouse gases, mainly CO_2 [27].

Autoclave Disinfection

Autoclave disinfection is a treatment method using temperature and steam simultaneously to kill microbes[17]. It is operated at a lower temperature than incineration but with pressure and steam influence to achieve disinfection[21]. The operating conditions are 60 min, at 121 C° and 1 bar, followed by a cycle of 60 min at 134 Cº to ensure the complete disinfection of waste [23]. The following aspects govern the operation of the autoclave [21]:

- Temperature (121–134 C°),

- Steam penetration,

- Waste load,

- Duration of the treatment cycle,

- Chamber air removal.

Due to the low operating temperatures of autoclaving, the waste appearance does not change, and the pathogens are not removed, which requires pre-treatment of the waste by incineration to be disposed of in landfills[17]. Thus, the autoclave is not optimum for all waste types.

Microwave Disinfection

Microwave disinfection uses low temperature and high microwaves for the reverse polymerisation and degradation of organic substances and microorganisms. The waves induce molecular bond vibrations, saving energy and preventing emissions, making it a more environmentally friendly method. The disinfection is operated at temperatures ranging between 177 and 540 Cº electromagnetic waves of wavelength ranging between 1 mm and 1 m and frequency ranges between 300 and 3000 MHz. Microwave disinfection has high costs and can be combined with incineration and autoclave [27]. The following aspects govern the operation of this method [23]:

- Waste characteristics,

- Moisture content,

- Microwave source strength,

- Exposure time,

- Degree of waste mixing.

Chemical Disinfection

Chemical disinfection is used to kill microorganisms and fight off pathogens by using chemicals . It is primarily used for treating liquid infectious waste such as blood, urine, feces, or hospital sewage. The chemical disinfectants that are commonly used are bleach solution

(1%) or a diluted active chlorine solution (0.5%). In addition, other disinfectants such as lime, ozone, ammonium salts, and peracetic acid can be used [21].

This treatment method directly affects those in charge of the treatment due to the inhalation of volatile chemicals or irritations to the skin and eyes [21]. The following aspects govern the effectiveness of this method [27]:

pH,

Contact time,

Waste and chemical mixing,

Recirculation versus flow.

The residues of this treatment are liquid and solid residues. The liquid residues are disposed of in the sewer system, and solid residues are disposed of in the landfill [28].

Waste Disposal

Rejects of the previous steps are transported to a sanitary landfill for disposal. However, landfills are not the optimum solution for handling MW due to their environmental effects. These effects are soil and water pollution caused by leachate and gas emissions into the air due to waste degradation [29]. Thus, the waste being disposed of should be minimized to the most, and achieving a circular economy guarantees that. Long-term decomposition of waste is the primary process responsible for waste disposal in landfilling[29]. Preventive measures should be taken to ensure the safe disposal of MW, which are [25]:

Rapid cover of waste,

Burying it under the old municipal waste of minimum burial of three months,

Waterproof bottom,

Minimum 2 m above the water

Emerging Technology

This method involves shredding and grinding the infectious medical waste bags via sharp cutting blades that are installed within the vessels. The blades rotate around 1750 revolutions per minute and the volume of the shredded waste is reduced by 80% [30]. The steps included in the process are loading, shredding, heating, sterilization, cooling, draining, vacuum and unloading. The whole process is enclosed in a compact system and there is no intermediate handling of the waste within the process. Due to its compact size, this system can easily be used for on-site treatment of waste and installed in hospitals. This will reduce the transportation costs of MW. In terms of environmental aspects, it is a clean and chemical-free technology and does not have any hazardous emission or radiation[30]. This method is economical and environmentally friendly and is reliable in terms of ease of use and maintenance. This technology is currently practiced in the middle eastern countries such as Iraq, Jordan, Kuwait, Lebanon, Syria, and UAE.

Similarly, a team of engineers in Idaho National Laboratory, USA have invented a new patented technology that helps in better management and treatment of MW. Based on this technology, Med-Shred, Inc., (Texas, USA) has developed a mobile shredding and chemical

disinfecting machine that is aimed for on-site treatment of hazardous MW[31]. The machine converts the MW into disposable municipal waste using shredders that shred the waste into smaller particles which are then wetted with disinfectant spray and immersed in a disinfection solution. The wet waste is then dried using a hot off-gas in a drying chamber. Considering the number of clinics and hospitals in middle east, this method will be very successful if utilized, as it can treat MW which helps in better management of waste.

Possible health risks of medical waste

It is difficult to measure the effects on the health of the population, bearing in mind that the concentrations of the effects of pollutants, which are present in the waste, predominantly small [32]. For most studies, waste management facilities are black boxes, which are supposed to emit toxic compounds, but without actual, quantified measurements that could be used in human health risk assessment[33]. Consequences caused by hazardous MW can be acute and chronic. After short-term exposure to dangerous substances, acute consequences occur, among which are burns caused by corrosive substances, eye irritation, inhalation of toxic gases. Chronic consequences occur after long-term exposure, and are difficult to predict, since they occur after several years, when their cause can hardly be determined[34]. Improper handling of MW represents a potential risk factor in the spread and transmission of infectious diseases. The risk group of transmission of infectious diseases includes primarily health workers, physicians and medical technicians, patients, staff employed in biomedical laboratories, logistics staff – hygiene services. This transmission is done through direct contact with the infected person and his body fluids, as well as indirectly through contaminated medical equipment. Precisely, percutaneous injuries are one of the most important risk factors for the transmission of

infectious diseases. Percutaneous injuries are divided into two types: injuries to the needles used in therapy and diagnosis and injuries to sharp objects (glass, scalpels). Centers for disease prevention and control from Atlanta in the United States indicate that about 1000 percutaneous injuries occur in hospital conditions daily[35]. The consequence of percutaneous injuries are microorganisms, i.e., causes of various infections in humans such as: infections caused by hemorrhagic fever viruses (e.g. Ebola), hepatitis B, hepatitis C, herpes, HIV, malaria, leprosy, typhus, syphilis, gonorrhea, diphtheria[36].

Conclusion

MW is highly hazardous and puts people at risk of fatal diseases. Understanding MW management and control techniques is important. In this paper, the definition of MW, MW management regulatory acts, the risks of exposure, MW management procedures and control techniques are presented. MW contributes to a considerable percentage of the total waste generated in most countries, and about 75% of MW is non-hazardous. The rest is hazardous since it is contaminated with infectious contaminants that can cause illness and transmit various diseases; therefore, proper handling and treatment of MW are needed. Better management can be implemented with appropriate (local) laws and regulations to reduce the risk of cross-contamination and decrease levels of emitted pollution from treatment and recycling of MW. In order to enhance MW management and treatment and make it more efficient and less damaging to the environment and to reduce the cost of production, disposal, and treatment, several aspects have to be considered: (i) to reduce the quantity of waste generated by regulating the use of materials and disposable equipment, (ii) to segregate the waste according to the regulations, with more strictness and attention, (iii) to limit the use of incineration, (iv) to follow stricter technological measures for the incineration of MW, e.g., filtration and

treatment of emissions from the incinerators, (v) to invest in new eco-friendly technologies for the disinfection and treatment of MW.

Conflict of Interest

The authors declare no conflict of interest.

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Original Article

NURSING INTERVENTIONS IN THE CARE OF PATIENTS AFTER THE PLACEMENT OF A CARDIAC PACEMAKER

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Abstract

Background: Nurses/technicians are an important part of cardiological teams that take care of patients with cardiac pacemakers. (CP) **Aim**: The aim of this study was to determine the healthcare of patients with CP and the role and attitudes of nurses/technicians in this process. **Materials and Methods**: Two samples of 30 patients with cardiac pacemakers and 20 nurses/technicians from the Clinical Centre Zvezdara in Belgrade, were interviewed with a Patient Survey consisted of 17 questions and a Nurse Survey with 13 questions (demographic data, clinical data, educational data and attitudes). **Results and Discussion**: The most common indication for a CP is symptomatic bradycardia (50%). The most frequent complication after

CP implantation was hematoma (30%). Most of the patients had symptoms of vertigo and fainting after the CP installation (80%), limited mobility (90%), and the average length of hospitalization of the patient was up to 7 days (50%). Most patients go for regular check-ups (93%). The degree of satisfaction of patients with the work of nurses shows that most of them are satisfied or very satisfied (80%). Most nurses/technicians are satisfied with the cooperation with patients (80%) and colleagues (95%) and generally believe that there is teamwork in the department (75%). Respondents generally believe that there is active family cooperation in education (85%). About two-thirds of nurses/technicians go to continuing education. **Conclusion:** This study in a Belgrade clinic shows that nurses/technicians largely contribute to satisfactory healthcare of patients with pacemaker.

Keywords: cardiac pacemaker, patients, health care

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Introduction

A cardiac pacemaker (CP), electro stimulator, or artificial heart rhythm guide was first implanted in the world in 1958. Since then, this device has largely changed its appearance, thanks to the development of electronics, and intervention is nowadays considered a routine procedure. CP appearance and its indications have changed with system development. The goal of stimulating the heart muscle is to establish a proper rhythm, which is why the stimulator is called a CP. If the heart muscle is preserved, but the activation mechanism is disturbed for some reason, the muscle can be artificially stimulated or inhibited and thus enable a completely normal life. A very weak stimulation current is required for its functioning.

In recent decades, CP therapy has gained an increasingly important place in the treatment of complex cardiac patients, the indications are becoming wider, and an increasing number of patients are being treated in this way. This has been achieved through better diagnostics, better education of medical professionals, as well as increased life expectancy in the general population. Patient care after CP implantation depends on the professional assessment of the patient by a nurse who is part of the cardiology team. As the closest to the patient, the nurse has a significant role in providing quality health care and education to these patients.

Anatomy of the heart impulse transmission

The specific conduction system[1] in the heart serves to maintain the heart rhythm and transmit the action potential through the heart muscles, which enables contraction. The conduction system of the heart, which functionally represents an inseparable whole, can be schematically divided into the following parts:

• Sinoatrial (SA) node

• Atrioventricular (AV) node

• AV bundle with branches left and right and

• A network of Purkinje cells

The rhythmic activity of the heart is initiated and controlled by an electrical signal, which is generated in specialized cells that form the SA node. The SA node has an oval appearance, 2 to 3 cm long, and about 5 μm in diameter[2]. It is in the right atrium in the back part of the interatrial septum, proximal to the mouth of the superior vena cava, at the junction of the superior vena cava and the right atrium. The SA node is connected to the AV node by anterior, middle, and posterior internodal pathways and one pathway to the left atrium.

The AV node is in the lower part of the central interatrial fibrous tissue, more on the right side. The AV node is divided into three parts: atrio-nodal, nodal, and nodal part of His. In the nodal part of His, cells of the AV node create a network of longitudinally distributed fibrils, which continues into the bundle of His. The bundle of His begins with the contraction of the AV node into a simple muscle network. It is divided into two parts: penetrating and branching (distal). The distal part of the bundle of His passes 5 to 15 mm downward into the ventricular septum towards the apex of the heart. Then the bundle is divided into left and right branches, which are located under the endocardium of the corresponding side of the septum. Each branch extends towards the top of the corresponding chamber, and there it divides into smaller branches that spread throughout the heart chambers and finally return to the base of the heart (network of Purkinje cells).

An action potential is generated in the SA node. The endings of the fibers of the SA node join the fibers of the atrial myocardium. In this way, the electrical signal, generated in the SA node, initiates the depolarization of the cells of the left and right atrium, which leads to the contraction of both atria and the pumping of blood into the ventricles. After that, repolarization and relaxation of the atrium muscle occurs. The electrical signal from the SA node passes to the AV node. The AV node and its associated conducting fibers are the main factor that slows the conduction of the cardiac impulse from the atria to the ventricles. This slowing of conduction allows sufficient time for the atria to empty their contents into the ventricles before ventricular contraction begins. The impulse, having appeared in the SA node, travels through the internodal pathways to the AV node in about 0.03 s. However, from then until the pulse reaches the bundle of His, an additional 0.09 s passes. The special feature of the His bundle is that it allows conduction in only one direction, forward from the atria to the ventricles[3]. The atrial muscles are separated from the ventricular muscles by a continuous fibrous barrier. This barrier

normally acts as an insulator preventing the passage of the cardiac impulse between the atria and ventricles by any route other than unidirectional conduction through the bundle of His. From the moment the cardiac impulse enters the bundle of His to the moment it reaches the terminations of the Purkinje fibers, about 0.03 s passes.

This means that once the cardiac impulse enters the Purkinje system, it spreads almost instantly over the entire endocardial surface of the ventricular muscle[2]. The final Purkinje fibers continue to the muscle fibers and when the heart impulse reaches the ends of the Purkinje fibers, it initiates the depolarization of the left and right ventricles, followed by their contraction and pumping of blood into the systemic, or pulmonary blood flow. After that, there is a repolarization of the ventricular muscles and their relaxation, and then a new cycle begins. The cardiac cycle is the period from the end of one ventricular contraction to the end of another contraction. It is divided into two periods: a period of relaxation, called diastole, during which the heart fills with blood; followed by a period of contraction, called systole.

The speed of conduction of the stimulus (action potential) from the SA node through the rest of the conduction system depends on several factors: the nature of the conductor and its diameter, the maximum diastolic potential, the stimulus threshold, the amplitude of the action potential and the speed of phase 0 of the action potential (Mohrman 2003)[4]. The velocity of impulse propagation in a normal human heart is:

- through the atria 1-2 m/s
- through the atrioventricular node 0.2 m/s
- through His bundle and its branches 2 m/s
- through the network of Purkinje cells 4-5 m/s
- through the myocardium 0.4 m/s

AV node fibers, when not stimulated by impulses from another source, send impulses at a frequency of 40 to 60 impulses per minute due to their own rhythmicity, and Purkinje fibers at a frequency of about 15 to 40 times per minute. These frequencies differ from the normal frequency in the SA node, which is 70 to 80 times per minute [3]. Each time the SA node sends an impulse, that impulse reaches the AV node and the Purkinje fibers and initiates depolarization of their membranes. After that, the mentioned tissues, as well as the SA node, recover from the action potential and become hyperpolarized.

In the SA node, the hyperpolarization is lost much faster than in the other two tissues, so the SA node transmits a new impulse before the membrane potential in the other two tissues has returned to the value of their own level of self-excitation. The new impulse again discharges both the AV node and the Purkinje fibers. It is constantly repeated, that is the SA node always re-stimulates other tissues that could self-excite, but before a spontaneous impulse can appear in them. Therefore, the SA node controls the heart's rhythm because the frequency at which it rhythmically transmits impulses is greater than the frequency in any other part of the heart. This is why the SA node is said to be the normal CP of the heart (often called the natural CP). If the lead is located anywhere outside the SA node, it is called an ectopic lead. In this case, certain parts of the heart will contract in an abnormal order.

Principle of CP operation

Many heart diseases are caused by improper synchronism between the information of the central nervous system and the sinoatrial node, or the sinoatrial node and the contractions of certain parts of the heart muscle. For example, if there is damage or a complete interruption of the nerve connection in the SA node - myocardium relationship, then the SA node receives

proper impulses from the brain, however, these impulses do not trigger synchronously with the myocardium. This manifests itself in various difficulties of the patient. An even more severe example is if the SA node stops working entirely. A CP is, in fact, an electrical stimulator that has the properties of an oscillator and is used to provide a rhythm to the myocardium. It consists of a power source, a pulse generator circuit, and a system of electrodes[5].

Today, there are already several types of CPs, but we can mainly divide them into two groups, namely[6]:

• internal CP - implanted

• external CP

According to the function they perform, CPs are divided into anti-bradycardia, anti-tachycardia with the potential to deliver a DC shock (ICD), as well as resynchronization. There are CPs with or without the ability to deliver a DC shock (CRT-P, CRT-D). Anti-bradycardia CPs ensure an adequate heart rate, and the prevention of Adam-Stokes syncope. According to the place of stimulation, anti-bradycardia CPs can be:

• AAI CPs with right atrial stimulation, in patients with sinoatrial (SA) node disease, and preserved conduction in the atrioventricular (AV) node.

• VVI CPs perform stimulation from the right ventricle, they are used in patients with a slow ventricular rate, when synchronization of the stimulation with the activity of the SA node is not possible (atrial fibrillation or atrial flutter).

• The DDD CP system stimulates the heart from the right atrium and right ventricle, used in patients with SA or AV node dysfunction, followed by a slow ventricular response. This is a physiological CP stimulation that allows synchronization of the work of the atria with the ventricles.

• VDD CP, used in AV node disease, with normal SA node function, so atrial stimulation is not required.

The mentioned types of anti-bradycardia CPs can be frequency adaptive, with the R (rate response) option used in patients with chronotropic competence[7]. With this function, thanks to the sensors, CPs provide an adequate increase in heart rate.

The implanted CP is characterized by the fact that, in addition to the electrodes that are in contact with the heart muscle, and the complete electronic part of the device with batteries for power, it is implanted inside the body. Therefore, an operative intervention is necessary for the installation of a CP. External CPs are located outside the body, only the electrodes are attached to the patient.

The biggest problem in the application of implanted CPs is their power supply. It is of interest to develop CP systems that, once installed, would function for the rest of the patients' lives without the need for subsequent surgical interventions. The original CPs used Hg-batteries (Hg-Zn cells), allowing the generator to last 30-36 months. Nuclear batteries, whose service life was over 10 years, were also used as an energy source, e.g., 5 Ci of 238 Pu. In those batteries, the radioisotope is a source of heat that is converted into electricity by the Zebeck effect. Due to the radioactive radiation that these energy sources emit, and other side effects for the patient, the use of these batteries is limited.

Implanted CPs in use today have lithium anode batteries. A lithium-iodine cell has a lithium anode and a cathode made of a mixture of molecular iodine and polyvinyl pyridine. There is no electrolyte in the cell itself since the lithium-iodide electrolyte is generated in a solid

aggregate state during chemical reactions between the anode and the cathode. As the thickness of the electrolyte layer increases with time, the internal resistance of the cell increases by 50-100 fi/month. The electromotive force of the cell drops sharply as all the iodine is extracted from the cathode. Another type of lithium cell is the so-called SAFT cell (acronym SAFT from Societe des Accumulateurs Fixes et de Traction, where this cell was constructed). It contains a liquid lithium-perchlorate electrolyte dissolved in propylene-carbonate, it is a lithium anode, while its cathode is made of a mixture of silver chromate and graphite. During the conversion of silver chromate to lithium chromate the cell voltage remains constant and then drops to a lower plateau as the chromate ion is converted to the much more stable chromium oxide. At the appearance of the second (lower) plateau, we can claim that the cell is emptying.

The construction of the generator is dictated by the following physiological parameters: heart rate and stimulation threshold. The pulse generator circuit usually contains an amplifier, an oscillator, and a voltage doubler. Considering the small dimensions of implanted CPs, these components (complete analog and digital circuits) are in a chip in an integrated technique[8]. The oscillator provides electric pulses of a certain frequency and duration, which are then fed to a voltage doubler where the pulse amplitude is regulated. The voltage doubler amplifies the pulse from the oscillator so that its amplitude reaches a value of about 5 volts when it reaches the electrodes.

On average, the parameter values of implanted CPs are as follows[8]: pulses are usually rectangular in the range of 40-120 beats/min. The pulse duration is usually between 2-5 msec and their amplitude is in the interval 5-15 volts. The amplifier serves to detect and amplify endocardial (heart) signals. For most generators, the detected signal should be greater than 2 mV. In addition, the amplifier defines a refractory period (most often 325 msec). After the

occurrence of the stimulation pulse or cardiac signal, the refractory circuit prevents signal detection in the amplifier for a given refractory period.

Via stimulation electrodes, the CP stimulates the heart, although in some models the same electrodes are used not only for stimulation, but also for recording ECG signals. The electrodes are connected to the generator via conductors, which usually have connections at the ends that create connections between the electrodes and the generator. This method of binding is justified because in the event of elemental failures or the need to charge the battery, the surgeon is able to remove the CP with a relatively simple operation while the electrodes still remain in place. Unipolar or bipolar electrodes can be used to stimulate the heart. Unipolar electrodes are applied by placing one electrode directly on or in the heart, while the other - a reference electrode - is placed in the immediate vicinity of the heart. Bipolar electrodes are placed so that both are on or in the heart.

Electrical stimulation works on an all-or-nothing basis. If the stimulation threshold and useful time are not reached, the action potential will not occur. Therefore, when the electrodes are placed in a stable position at the top of the chamber, an electrical test is used to check whether good contact of the electrode with the myocardium has been established, and the irritation threshold is determined.

The stimulation threshold is determined as follows: a pulse of amplitude 5 volts and a duration of 2 msec is usually sufficient to cause electrostimulation of the myocardium, that is, to realize the spread of depolarization from the point of contact of the electrode, which can be seen on the electrocardiogram that is recorded in parallel. We gradually decrease the pulse voltage until the ECG signal is lost, and after that we increase the pulse voltage up to the irritation threshold. ECG characteristics of CP stimulation are (ACC 2002)[9]:

• CP stimulation from the apex of the right ventricle presents with wide QRS complexes, with about 140 msec in healthy myocardium, and up to 200 msec in the case of conduction through scar tissue.

• CP stimulation from the apex of the right ventricle has a pattern like left bundle branch block

• It is characterized by a negative vector in DII, IIIaV, aVf, and a positive one in DI.

Indications for a CP

- The most important indications for CP implantation are:
- Complete AV block, intermittent or permanent, associated with:
- symptomatic bradycardia,
- arrhythmias or other medical conditions that require the use of drugs that suppress automaticity and lead to symptomatic bradycardia,
- a documented period of asystole longer than 3 seconds or an escape rhythm lower than 40/min, - after ablation of the atrioventricular (AV) node, if the procedure modifies the AV node,
- postoperative AV block, which is estimated to be a permanent change, neuromuscular diseases with AV block, - AV block second degree chronic or intermittent with symptomatic bradycardia ,
- symptomatic bradyarrhythmia with RR interval over 3 seconds [10].

Electro stimulator implantation is a surgical procedure during which all surgical principles must be observed. It is performed in a surgical room that must have a fluoroscopy machine or in a catheterization room. In addition to surgical instruments, it is necessary to continuously monitor the patient, a defibrillator and a suitable programmer that will examine the so-called

stimulation threshold after electrode positioning. The classic electro stimulator is implanted on the right side, unless the patient requests otherwise for some reason (hunters, fishermen, etc.). Patients are usually not given premedication and the patient does not take a meal before the intervention. An incision is made to the right or left in the prepectoralis sulcus, and the electrode is placed over the cephalic vein or over the subclavian vein. With two-chamber and multi-site CPs, we use both veins because it is necessary to implant two or three electrodes. After the intervention, the patient (unless a screw-on electrode is used, the so-called srewing) usually lies in bed that day, and is already able to get up the next day. Most often, the intervention passes without complications, but they still exist and do happen.

Complications after CP implantation

The most common complications after the installation of a CP are pneumothorax (which occurs when a subclavian vein is punctured) or hemothorax (which occurs if a blood vessel is lacerated), perforation of the myocardium with an electrode, dislocation of the electrode (the displacement of the electrode from the place where it was placed is accompanied by a loss of pacing or an increase in the threshold stimulation) exit block, (increasing the stimulation threshold of the electrode even though it did not move due to fibrosis of the place where it is located), arrhythmias during manipulation of the electrode, extracardiac stimulation, decubitus of the CP bed (due to battery pressure), and infection at the implantation site.

Death from complications is rare, however. The mortality rate is 0.08-1.1%[11]. The most common complication is displacement of the electrodes (there is a higher frequency of displacement of atrial than ventricular electrodes), followed by pneumothorax, infection, hematoma, and perforation of the heart.

Pneumothorax is a serious complication of implanting an electro stimulator, and it most often occurs due to the use of the subclavian vein puncturing technique. In the literature, there are different data on the incidence of pneumothorax when puncturing the subclavian vein, so the incidence varies from 0.6-1%, while on the other hand, there is data in some studies that indicate an incidence of 5.2%. However, the incidence is generally considered to be 1-3%[11]. After puncture of the subclavian vein, pneumothorax usually occurs ipsilaterally. Although cases of contralateral pneumothorax due to perforation by an endocardial atrial lead have also been described, it is still a rare complication. If it does not compress more than 30% of the lung parenchyma, and if severe symptoms or hemothorax have not developed, it is treated by draining the pleura through the 2nd intercostal space in the medio clavicular line directly into the pleural space.

Hemothorax is an extremely rare complication of electro stimulator implantation. It is usually caused by puncturing the subclavian artery and introducing a venous electrode into it. Hemothorax is usually treated with drainage, although in rare cases decortication is required.[12]

Air embolism is a complication associated with the use of Seldinger's percutaneous puncture technique[11] Deep inspiration during the use of venous access can lead to the introduction of air into the venous system due to the development of physiological negative pressure. To prevent this complication, it is recommended that the patient be well hydrated and placed in the Trendelenburg position. However, the most important step in the prevention of air embolism was the awareness of the doctor performing the implantation procedure about the possibility of developing the complication itself. The risk group for the development of air embolism is

elderly, dehydrated patients, and the riskiest part of the installation procedure is the extraction of the dilator from the venous introducer.

Venous thrombosis is a rather rare, but at the same time dangerous complication of electro stimulator implantation. It occurs at different time intervals after procedure[12].

Depending on clinical studies, the incidence of venous thrombosis is 30-45%, but most of them remain asymptomatic because adequate collateral circulation develops. The pathogenesis is not fully clarified, the literature mentions several risk factors that could influence the development of severe occlusion: the presence of multiple electrodes (compared to single-electrode systems), use of hormonal therapy, anamnestic data on previous venous thrombosis, previous electrostimulation therapy , endothelial trauma caused by electrode insertion and postoperative hypercoagulable state. Although only 1-3% of patients with venous thrombosis develop symptoms, it is necessary to routinely monitor and pay attention to the possible development of this complication because early diagnosis can reduce potential morbidity or mortality. The clinical picture depends on the place and size of the thrombosis.

Hematoma is a relatively common complication of electro stimulator implantation, especially in patients who are on oral anticoagulant or antithrombotic therapy. The introduction of perioperative anticoagulant therapy is a dilemma for doctors, especially in people with a medium to high risk of developing thromboembolism. Current guidelines recommend discontinuation of oral anticoagulant therapy and "bridging" therapy with heparin. However, the "bridging" strategy of heparin therapy was associated with an increased incidence of bed hematoma (up to 20%), and numerous observational studies later showed that the continuation of oral anticoagulant therapy is safe and does not increase the incidence of hematoma.

Wound erosion and dehiscence are subacute complications of CP implantation caused by progressive skin erosion. If the bed prepared for the generator during installation is too small for the device, the excessive tension of the skin covering the bed may gradually cause erosion of the subcutaneous tissue and possibly the skin. Erosion can also occur if the bed is placed too superficially, therefore the bed should be placed on the surface of the muscle. In the case of erosion, there is a high risk of infection, and therefore a complete extraction of electrodes and devices is recommended[7]. As the number of implanted devices increases, so does the incidence of infections associated with the implantation of electro stimulators. The complication can affect any structure - from generator beds and electrodes to endocardial structures, the latter of which is associated with extremely high mortality. Multiple and prolonged hospitalizations are common and attempts to rescue infected devices regularly fail. In the literature, the incidence of infections as a complication of the installation of all cardiac electronic devices is reported to be from 0.5 to 2.2%, with a slightly lower incidence if it is a question of permanent electro stimulators compared to implantable cardioverter defibrillators, and a slightly higher incidence if it is a question of a repeated procedure compared to the primary one.

Ventricular electrode malposition is an extremely rare complication, and cases of malposition in several different locations are described in the literature: left ventricle, coronary sinus, cardiac veins, and pulmonary blood vessels[13].

Electrode dislocation is a clinically significant and potentially dangerous complication. It usually appears in the early post-implantation period (within 24-48 hours). 88% of dislocations occur within the first 3 months, and a case of electrode dislocation 10 years after implantation is described in literature[14]. Atrial electrode dislocations are more common than ventricular dislocations. The incidence of atrial electrode dislocation is 1.6-4.4%, while the incidence of

ventricular electrode dislocation is 0.5-1.9%[12]. Possible risk factors for the occurrence of electrode dislocation are NYHA IV, atrial fibrillation and performing the procedure by an inexperienced physician. After dislocation, the lead usually remains intracardial. However, some mechanisms that cause electrode dislocation lead to the electrode being pulled toward the generator.

The aim of this work was to determine the importance of planned health care for patients after CP implantation, as well as the role of nurses/technicians in this process.

Materials and Methods

In this research, we used a questionnaire survey instrument, one specially designed for patients and one for nurses-technicians

The research instrument is a survey sheet containing a Patient Survey with 17 questions (demographic data, clinical data, attitudes) and a Nurse Survey with 13 questions (demographic data, educational data, attitudes).

Sample

The sample consisted of 30 patients of both sexes who had a CP implanted at the cardiology department of the KBC "Zvezdara" in Belgrade. The second sample consisted of 20 nurses/technicians working in this department. The research was conducted from June 1 to June 30, 2022.

Statistical Analysis

The statistical method we used was descriptive statistics made in the SPSS 17 program and presented in tables and graphically with absolute and relative numbers.

Results and Discussion

Patients

Distribution of respondents by gender shows that the frequency of males (24; 80%) is four times higher than females (6; 20%). The synergistic or opposing effects of sex and gender on cardiovascular traits and on ischemic heart disease and heart failure mechanisms have not yet been systematically described. Specific considerations of sex-related and gender-related factors in gender dysphoria or in heart-brain interactions and their association with cardiovascular disease are still lacking [14,15]

The results show that every other respondent (15; 50%) with an implanted CP is in the age category of 61-70 years, 30% 8 is over 70 years old, while 20% (6) is under 60 years old.

According to the level of education, most respondents (11;36%) completed secondary school, 20% (6) college, 17% (5) high school, 20% (6) university, while 7% (2) completed elementary school.

The largest share (14; 47%) of respondents live in a suburban settlement, 33% (10) lives in a city, while 20% (6) lives in rural areas .

As many as 80% (24) of respondents had symptoms of vertigo and fainting after the CP installation, while 20% (6) did not.

The results show that 90% (27) of subjects had limited mobility after CP implantation, while 10% (3) did not.

Every other respondent (15; 50%) was hospitalized for up to 7 days, 30% (9) for 8-10 days, while 20% (6) were hospitalized for more than 10 days.

The perception of pain on the Norton scale after CP implantation was mild for the majority (12; 40%) and scored from 0 to 2, 33% (10) of respondents assessed the pain as moderate (3-5), 20% (6) as moderately strong (6-8), while 7% (2) assessed it as severe pain (9-10).

A need for analgesics had 20 (67%) of respondents, while 10 (33%) did not.

As many as 93% of respondents went to regular CP checkups, and 7% did not go to checkups regularly.

As many as 28 (93%) of respondents went to regular CP checkups, and 2 (7%) did not go to checkups regularly.

The largest share (27; 90%) of the respondents stated that they received instructions on daily activities, while 3 (10%) claimed that they did not.

The results show that 21 (70%) of the respondents claimed to have received instructions on physical activities after CP implantation, while 9 (30%) did not.

Most respondents (50%) received instructions about activities after CP implantation from nurses, 30% from doctors, 13% from the Internet, while 7% did not receive instructions.

As many as 29 (97%) of respondents stated that they had received information about contraindicated procedures after CP implantation, while only one (3%) stated that they had not received this information.

The results indicate that 12 (40%) respondents are very satisfied with the work of nurses, 40% (12) are satisfied, while 20%(6) are not satisfied.

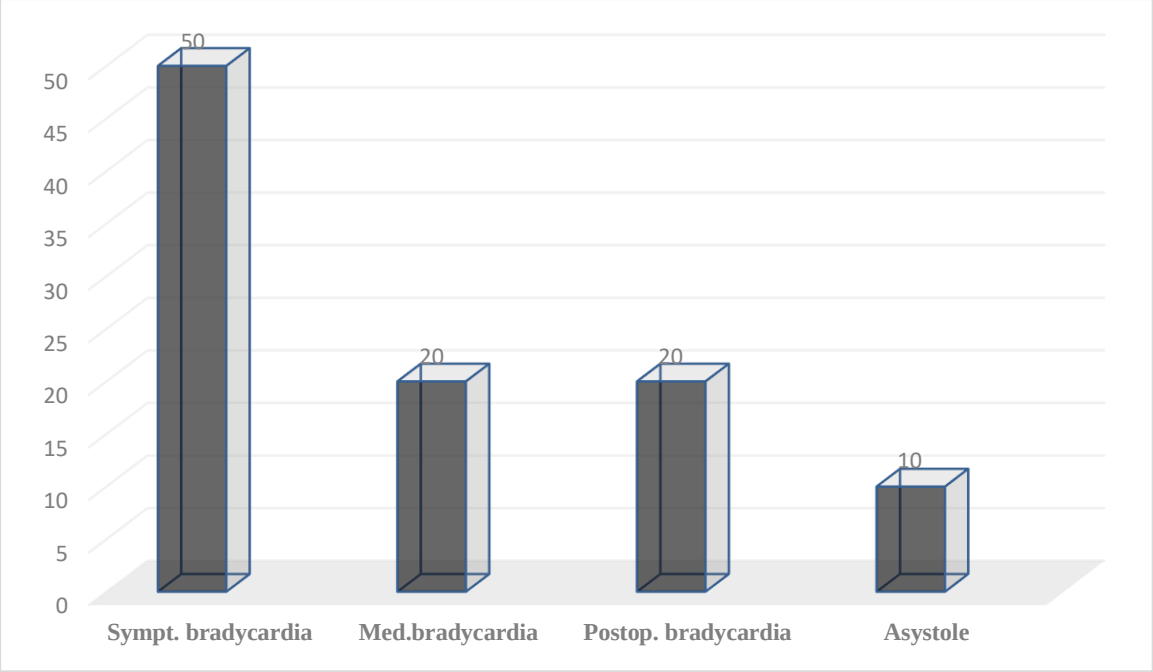

Figure 1. Distribution of respondents by the indication for cardiac pacemaker

In every other subject (50%), the indication for the implantation of a CP is symptomatic bradycardia, in 20% it is medication bradycardia, in 20% postoperative bradycardia, while short-term asystole is the indication in 10% of subjects (Figure 1).

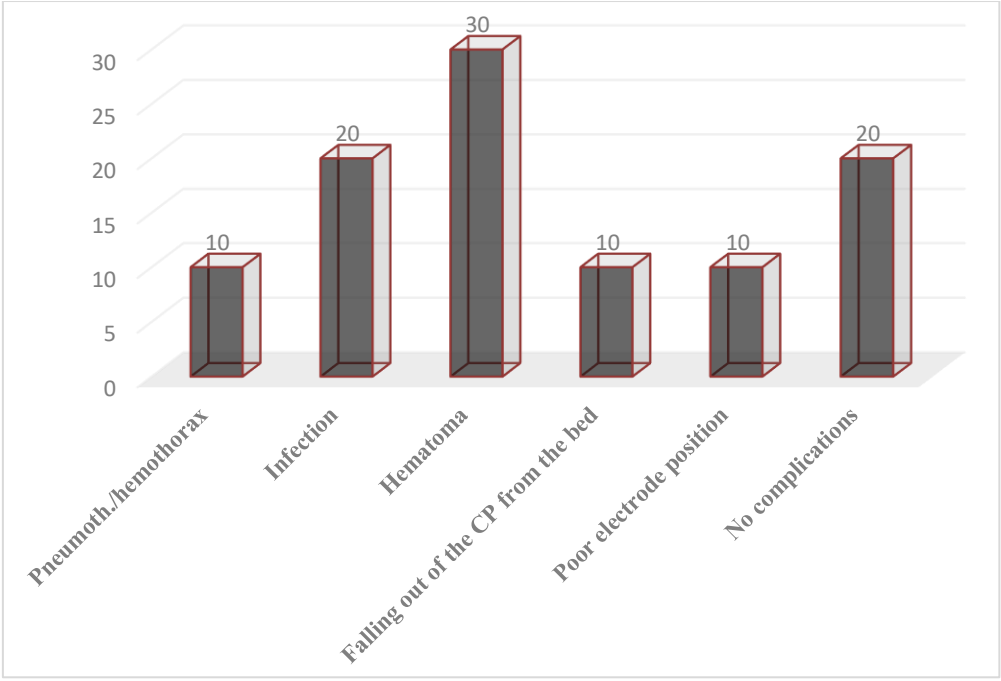

Figure 2. Complications after pacemaker implantation

The most common complication was hematoma at the implantation site, which occurred in 30% of subjects, in 20% infections, 20% had no complications, 10% had pneumothorax or hemothorax, 10% CP falling out of the socket and 10% electrode malposition. Many studies indicate that the most common complication is hematoma [16]. As many as 80% of respondents had symptoms of vertigo and fainting after the CP installation, while 20% did not. Vertigo is expected after the intervention, as our results indicate (Figure 2).

Nurses/Technicians

Respondents are predominantly female (16;80%), while 20% (4) are male. Half (50%) of respondents (10) are in the age category 31-40, 40% (8) are under 30, while 10% (2) are over 40. According to the level of professional education, the majority (8;40%) of respondents have a secondary education, 30% (6) have a higher education, while 30% (6) have a university education. The results show that 40% (8) of respondents had a length of service of up to 5 years, 40% (8) had 5-10 years, while 20% (4)had more than 10 years.

Half (10; 50%) of respondents are satisfied with cooperation with patients, 30% (6) are very satisfied, while 20% (4) are dissatisfied. The results show that 45% of respondents (9) are very satisfied with the cooperation with colleagues, 40% (8) are satisfied, while 15% (3) are dissatisfied.

The results show that 70% of respondents (14) participate in continuous education, while 30% (6) do not. Half (10; 50%) of respondents claim that they often go to education, 30% (6) rarely, while 20% of respondents (4) do not go to education. More than half (11; 55%) of respondents had education about patient care after CP implantation in the last year, while 45% (9) had not.

The largest share (15; 75%) of respondents is of the opinion that teamwork exists in the CP department, while 25% (5) do not share this opinion. In the opinion of 85% of respondents (17), the family shows cooperation in patient care, while 15% (3) think that this cooperation does not exist. The results show that 40% of respondents have the opinion that patients are satisfied with health care, 30% believe that they are satisfied, while 30% believe that they are dissatisfied.

Conclusion

Based on the research carried out at the department of cardiovascular diseases of KBC "Zvezdara", we reached the following conclusions:

Most patients are male, average age 61-70 years. The most common indication for CP is symptomatic bradycardia. The most frequent complication after CP implantation was hematoma, while every fifth respondent had no complications. Most of the subjects had symptoms of vertigo and fainting after the CP installation, limited mobility, and the average length of hospitalization of the patient was up to 7 days. Most respondents go for regular check-ups. The degree of satisfaction of the respondents with the work of nurses shows that most of them are satisfied or very satisfied.

Socio-demographic characteristics of nurses show that respondents are mostly younger, predominantly female. Most often, they have a secondary vocational education. Most respondents are satisfied with the cooperation with patients and colleagues and generally believe that there is teamwork in the department. Respondents generally believe that there is active family cooperation in education. Almost two-thirds of respondents go to continuing education. Most of the education is given at professional lectures.

This study in a Belgrade clinic shows that nurses/technicians largely contribute to satisfactory healthcare of patients with pacemaker.

Conflict of Interest

The authors declare no conflict of interest.

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Review Article

SECONDHAND SMOKE AND ITS UNFAVORABLE ASSOCIATIONS IN VULNERABLE POPULATION GROUPS

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Abstract

Secondhand smoke (SHS) is one of the greatest and most frequent environmental toxic exposures. According to WHO it causes over 600,000 deaths per year, the majority (64%) among women, with more than a third of all people exposed to the harmful effects of smoke. This corresponds to 1% of the global burden of diseases worldwide. Numerous studies have shown the harmful effects of SHS on those who are exposed, including female adults, children, and pregnant women and their fetuses. The aim of this narrative review is to present research concerning SHS and its unfavorable association with the physical and mental health of those vulnerable population groups. Full papers in the English language were searched in the PubMed, Google Scholar, and Web of Science databases and the inclusion factors were reviews and original studies on secondhand smoke and its effects on maternal and child health, including US Surgeon General's Reports since the year 2006. Special attention was paid to studies based on the bilateral American-Slovak project "Prenatal, pregnancy and childhood exposures to household smoking and their relations to subsequent development and health in

Slovakia". The research on SHS and health effects helps in campaigns for smoke-free environments and in the promotion of community-based smoke-free programs. Besides school and workplace, a complete smoking ban at home should be considered to avoid potential adverse health effects on vulnerable population groups.

Keywords: secondhand smoke, maternal health, child health

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Introduction

Secondhand smoke (SHS) is one of the greatest and most frequent environmental toxic exposures, according to WHO it causes over 600,000 deaths per year, with more than a third of all people exposed to the harmful effects of smoke. This corresponds to 1% of the global burden of diseases worldwide[1]. Numerous studies have shown the harmful effects of SHS on those who are exposed, including adults, children, and pregnant women and their fetuses [2-7]. Although the majority of smokers are men, many women and children are affected by SHS, and worldwide, SHS causes an estimated 600 000 premature deaths a year, the majority (64%) among women[1].

SHS is the smoke discharged from the lit end of a burned tobacco product as well as the smoke inhaled by a smoker and then exhaled into the environment during active smoking. There are more than 4000 chemicals in SHS, and more than 250 are known to be toxic[8,9]. Components of chemical compounds in secondhand smoke, including nicotine, carbon monoxide, and tobacco-specific carcinogens, can be detected in the body fluids of exposed nonsmokers. These

exposures can be controlled. Currently, cotinine, the primary proximate metabolite of nicotine, remains the biomarker of choice for assessing secondhand smoke exposure[7,8,9]. Thirdhand smoke is the residual matter from tobacco smoke that collects on surfaces and in the dust; the residual tobacco smoke pollutants remain on the clothes and hair of smokers and on surfaces, furniture, and dust in indoor environments. Exposure can persist long after smoking has stopped, through contact with smokers, and in indoor spaces in which tobacco is regularly smoked. Many components of thirdhand smoke are the same as SHS, but there are additional biologically active chemicals in thirdhand smoke that are formed from the reaction of SHS particles with chemicals such as ozone and gaseous oxide[10-12].

The 2006 US Surgeon General's Report, The Health Consequences of Involuntary Exposure to Tobacco Smoke states that ''secondhand smoke causes premature death and disease in children and in adults who do not smoke[9]. The report cites many physical health risks associated with exposure to SHS for which there is sufficient evidence to infer a causal relationship. These include Sudden Infant Death Syndrome; low birth weight; childhood respiratory infections; middle ear disease; childhood cough; asthma; lung cancer; and coronary heart disease, among others (Table 1). The report notes the growing literature showing an association between SHS exposure and child mental health and neurocognitive problems but concludes that the current data are insufficient to infer a causal relationship between this exposure and child mental health or cognitive functioning[9]. Since that report, more evidence has linked SHS exposure to a number of adverse health consequences, such as lower levels of breast-feeding, poorer academic performance in adolescents, child, and family food insecurity, bladder cancer in nonsmoking women, as well as fetal DNA damage and other problems[5,13-16]. The 2016 US Surgeon General's Report, E-Cigarette Use Among Youth and Young Adults deals with the public health issue of electronic cigarettes and their impact on young people[17].

The latest 2020 US Surgeon General's Report highlights the latest scientific evidence on the health benefits of quitting smoking, as well as proven treatments and strategies to help people successfully quit smoking[18].

Table 1. The health consequences causally linked to secondhand smoke

Children	Adults
Middle ear disease	Stroke
Respiratory symptoms, impaired lung function	Nasal irritation
Lower respiratory illness	Lung cancer
Sudden infant death syndrome	Coronary heart disease
Congenital defects – maternal smoking: orofacial clefts	Reproductive effects on women: low birth weight

Source: Office on Smoking and Health (US). (2006) The Health Consequences of Involuntary Exposure to Tobacco Smoke: A Report of the Surgeon General[9]

The aim of this narrative review is to present research concerning SHS and its unfavorable association with the physical and mental health of vulnerable population groups (women, pregnant women, children, adolescents, and young adults).

Material and Methods

Full papers in the English language were searched in the PubMed, Google Scholar, and Web of Science databases from the release of the US Surgeon General's Report 2006 to August 2023 using keywords "secondhand smoke" and "health effects" and "children" and

"adolescents" and "young adults" and "women or females" and "pregnant women" and "review". The inclusion factors were reviews and original studies on secondhand smoke and its effects on maternal and child health. Special attention was paid to studies based on the bilateral American-Slovak project "Prenatal, pregnancy and childhood exposures to household smoking and their relations to subsequent development and health in Slovakia". The results are classified into three sections: effects on maternal health, effects on child health, and intervention possibilities.

Results and Discussion

Effects on maternal health

Physical health

Smoking is a modifiable risk factor for adverse maternal and neonatal outcomes and is associated with maternal, fetal, and infant morbidity and mortality[9]. The disease risks from smoking by women have risen sharply over the last 50 years and are now equal to those for men for lung cancer, chronic obstructive pulmonary disease, and cardiovascular diseases[9]. As shown in previous research, active and passive maternal smoking during pregnancy increases the risk of having a child with low birth weight [19,20] and significantly increases other negative pregnancy outcomes, such as preterm birth[20,21,22], respiratory distress[23], antepartum and intrapartum stillbirth [22,23,24], perinatal death [22,23,25], long-term morbidity in offspring, and sudden unexpected infant death [7, 22,23,25].

Sudden infant death syndrome (SIDS) is generally defined as ''the sudden unexpected death of an infant less than 1 year of age, with the onset of the fatal episode apparently occurring

during sleep, that remains unexplained after a thorough investigation, including the performance of a complete autopsy and review of circumstances of death and the clinical history''.[17, 26, 27]. Nicotine may play an important role in increasing the risk of SIDS in infants of smokers. In animal models, exogenous nicotine administered to pregnant rats alters the expression of nAChRs (nicotinic acetylcholine receptors) in the brainstem in areas involved in autonomic function and affects fetal autonomic activity and medullary neurotransmitter receptors. In studies of human infants, prenatal tobacco exposure affects recovery from hypoxia in preterm infants; infants also display impaired arousal patterns that correspond to cotinine levels [17,27].

The World Health Organization and many other international groups have assiduously reviewed the evidence linking prenatal and childhood SHS exposure and SIDS, and it is now accepted by the scientific, public health, and pediatric communities that tobacco exposure is the most common preventable cause of SIDS[7.28].

According to the Global Adult Tobacco Survey (GATS) (2008–2010), which investigated the prevalence of smoking and passive smoking among women aged 15–49 years in 14 low- and middle-income countries, the prevalence was 0.4% in Egypt, 30.8% in Russia, 17.8% in Mexico, and 72.3% in Vietnam. In Poland, 26.9% of women smoke, 45.4% are exposed to ETS at home, and 24.3% are at work. Slovakia and the Czech Republic did not take part in this survey [29]. According to the WHO, the prevalence of daily adult tobacco smokers in Slovakia in 2021 was 24 % (a decrease since 2016 of 5 %). In Serbia the prevalence of daily adult tobacco smokers in 2021 was 33 % [30,31].

The ideal biomarker for SHS exposure has yet to be identified. Currently, the same markers used to measure active smoking are used to measure SHS exposure. Exposure to SHS is assessed indirectly by measuring the concentrations of carbon monoxide, thiocyanate, or nicotine metabolites such as cotinine. Although carbon monoxide and thiocyanate can reflect SHS exposure, they are not specific because they are found in multiple sources and can be produced from exposures to agents other than SHS. Cotinine is a direct metabolite of nicotine that has a longer half-life and a high specificity for SHS exposure. This chemical freely crosses the placenta and accumulates in fetal tissues. Cotinine can be measured in saliva, blood, or urine, and indicates the amount of nicotine exposure over the past 3 days. After birth, breast milk is a potential source of nicotine exposure. Nicotine and cotinine can accumulate to concentrations two- to three-fold higher in breast milk than in plasma. New methods of postnatal cotinine detection, such as liquid chromatography-tandem mass spectroscopy, are being developed to quantitatively estimate exposure to SHS[7].

The results of several existing studies indicate that smoking prevalence based on self-report closely approximates estimates assessed by cotinine concentrations. The discrepancy among self-reported smokers and nonsmokers may be due to different smoking patterns, including low nicotine dosing or SHS exposure and misreporting regarding smoking status [8,9,17,18].

Tobacco smoke contains toxic, carcinogenic, and mutagenic chemicals as well as free radicals and reactive oxygen species with potential oxidative damage to biomolecules. The increased production of reactive oxygen species is related to the depletion of antioxidants and the formation of oxidative stress in the organism [32,33]. As a result, lipid oxidation, cell membrane damage, DNA (deoxyribonucleic acid) strand breaks, and the inactivation of some enzymes may occur [34]. Exposure of pregnant women to tobacco smoke causes oxidative stress not only in pregnant women but also in their fetuses [35,36].

The study based on the bilateral American-Slovak project “Prenatal, pregnancy and childhood exposures to household smoking and their relations to subsequent development and health in Slovakia” was designed to evaluate environmental, behavioral, and psychosocial factors in the lives of mothers, pregnant women, and children living in the ordinary household with smokers [6,8,37]. In the sample of pregnant women the association of SHS with physiological, biochemical, and psychological indicators, as well as with urine antioxidant capacity (AC) and oxidative damage was investigated. Results of the study indicate that SHS-exposed pregnant women are under increased oxidative stress, pregnant women exposed to SHS had significantly higher oxidative damage to lipids and significantly lower urine antioxidant capacity than nonsmoking pregnant women not exposed to passive smoking. Overall, data from the study show that maternal cigarette smoking and SHS exposure during pregnancy may compromise the balance between reactive oxygen species and antioxidant defense and might cause potent oxidative stress with negative consequences in pregnancy. Validating the maternal self-report of smoking with the level of urine cotinine concentration could improve the precision of the assessment of exposure to tobacco smoke. In the study, self-report was in strong agreement with validation by cotinine assessment (78% agreement). Sensitivity was 66.7% and specificity 100%. The results of the study might be used in clinical practice and in campaigns for smoke-free environments and in the promotion of community-based smoke-free programs. Furthermore, they represent an important argument for intervention in families. A complete smoking ban at home should be considered to avoid potential adverse effects on pregnancy outcomes due to passive smoking[8].

Mental health

Mental health is an integral and essential component of health**.** The WHO constitution states: "Health is a state of complete physical, mental, and social well-being and not merely the

absence of disease or infirmity." An important implication of this definition is that mental health is more than just the absence of mental disorders or disabilities [40,41]. Mental health is a state of well-being in which an individual realizes his or her own abilities, can cope with the normal stresses of life, can work productively, and is able to contribute to his or her community [42]. Mental health is fundamental to our collective and individual ability as humans to think, emote, interact with each other, earn a living, and enjoy life. On this basis, the promotion, protection, and restoration of mental health can be regarded as a vital concern of individuals, communities, and societies throughout the world [42].

Mental and social well-being are inherently subjective and assessed in practice by self-report of health status. Short Form 36 (SF-36) and Short Form 12 (SF-12) are widely used instruments that collect information about eight areas of health and functioning. Lower (i.e., worse) scores on these instruments have been found to predict mortality and hospitalization [43, 44].

There is significant separate research showing the effects of maternal mental and physical health on child wellbeing. Mother's mental health, particularly maternal depression, has been clearly linked to many childhood problems, including worse child nutrition, poorer growth and development, more diarrheal illnesses, and other childhood problems[45,46,47]. Poor physical or mental function—assessed through SF-36 or SF-12 scores or reports of difficulty with specific tasks—was evaluated in several studies. In the Nurses' Health Study (NHS) cohorts, current smokers had poorer physical and emotional functioning than never smokers. Furthermore, among current smokers, physical and emotional function declined as the number of cigarettes per day increased[48].

Studies conducted in other countries have announced poorer physical and/or emotional health status among current smokers compared with never-smokers. [49,50]. In the very few studies conducted second-hand smoke exposure has been shown to be associated with mental health outcomes among non-smokers [6,38,39].

The study from Japan assessed the relationship between passive and active smoking to depressive symptoms in large samples of working males and females in a suburb of Tokyo in 2002. Self-reported smoking history and exposure to passive smoking at work and at home and depressive symptoms according to the Center for Epidemiologic Studies Depression Scale were assessed. Passive smoking at work and current smoking appeared to be associated with higher levels of depressive symptoms. Exposure to passive smoking at work was associated with a higher prevalence of depressive symptoms providing possibly indirect evidence of a causal link from cigarette smoking to depressive symptoms [38]. The study published on nationally representative data from the 2000 to 2004 Medical Expenditure Panel Survey in the USA showed a relationship between living with smokers and worsened maternal physical and mental health in non-smoking mothers with children. The risk was discernible with the presence of a single adult smoker in a household and increased with the number of smokers. Scores on the Medical Outcomes Short Form-12 (SF-12) Physical Component Scale (PCS) and Mental Component Scale (MCS) were used to assess maternal health[6]. This was one of the first studies showing an association between exposure to SHS and worse maternal mental health. The study specifically addresses the issue of mothers' health because of their profound contribution to the health, development, functioning, and quality of life of children. There is a great deal of evidence to show that mothers suffering from depression are impaired in their ability to care for their children. Smoking behavior is strongly influenced by the social environment. Findings from demographic bivariable analyses in this study demonstrate the

significant associations between household composition and secondhand smoke exposure among non-smoking mothers in the USA.

Despite some limitations (self-reported passive smoking and self-reported mental and physical health) the results are important, not only because they are some of the first to show an association between SHS and maternal mental health, but also because of their implications for the health and wellbeing of children[6].

In the cross-sectional study on the large community sample among Korean middle-aged and elderly never-smoking women, exposure to SHS was significantly associated with depression on the Beck depression inventory[39]. According to Korean authors, secondhand smoke itself can be stressful for non-smokers and the chronic stress may lead to the development of depressive symptoms. In addition, smoking partners are likely to have other adverse health-related behaviors and poor socioeconomic characteristics. The limitations of that study were the cross-sectional design and an interviewer-assisted measurement of the degree of SHS and depressive symptoms using a questionnaire[39].

Effects on child health

Children and adolescents are at particularly high risk for tobacco exposure through prenatal exposure secondary to maternal smoking and/or maternal exposure to SHS; exposure to SHS or thirdhand smoke during childhood or adolescence; and active firsthand smoking during adolescence [7,10,17]. Children spend most of their time lower to the ground where environmental dust with thirdhand smoke particles is present in the highest concentrations. [9,10] According to the Surgeon General of the U.S. Public Health Service, the most important environmental tobacco smoke exposure for children occurs in the home [9,10,17,51]. There is no safe level of

exposure to tobacco smoke, and tobacco continues to be the leading cause of preventable premature death worldwide. The physical effects of prenatal tobacco exposure involve almost every developing organ system, including the lungs, brain, heart, and ears. Infancy is the postnatal period with the highest risk of respiratory, neurologic, and immunologic morbidity. Children are particularly vulnerable to SHS due to their smaller lungs and less developed immune systems. Exposure to SHS in children results in respiratory illnesses, chronic respiratory symptoms (such as asthma), ear infections, and reduced lung function. Children of smoking mothers have more episodes of respiratory illness. There is a clear link between smoking in the home and the hospital admission of children for pneumonia and bronchitis[7,9,10,54,52].

Prenatal exposure to tobacco and postnatal exposure to SHS are leading preventable causes of SIDS, and have been associated with intrauterine growth restriction, low birth weight, and decreased head circumference. They are also associated with health problems during early and middle childhood, including upper respiratory tract infections, lower respiratory tract infections and decreased pulmonary function, asthma, otitis media, dental caries, hearing loss, and metabolic syndrome. Studies have found that children living with smokers are twice as likely to experience food insecurity as children living with non-smokers are. This food insecurity is associated with poor physical health, neuropsychological development, and poor academic achievement in children [5,7,10,13-16,27]. Animal models have shown that nicotine has teratogenic effects on neurodevelopment and marked alterations in neurotransmitters and neuronal pathways. [7,9,10].There is also evidence among human studies that exposure to tobacco smoke, both in the prenatal and postnatal periods, increases the risk of poor behavioral and cognitive outcomes in children, including conduct disorder, attention-deficit/hyperactivity disorder, and additional cognitive impairments[3,7,10,53, 54].

The rates of complications decrease as children age, partly since older children spend less time in the presence of parents, and therefore are exposed to lower levels of SHS[7,9,10,31,37,52].

In another study based on the bilateral American-Slovak project "Prenatal, pregnancy and childhood exposures to household smoking and their relations to subsequent development and health in Slovakia" the status of physical and mental health of children in relation to exposure to tobacco smoke was examined in a representative group of 1,478 school children. The methods used included anonymous questionnaires filled in by parents, Columbia Impairment Scale (CIS), Behavior Problem Index (BPI), and anthropometry. A significant association was found between exposure to tobacco and age, socio-economic status, incompleteness of the family, level of mother's education, and a higher prevalence of respiratory diseases. Emotional and behavioral functions of school children showed mostly the predominant impact of social factors lowering the apparent impact of SHS in bivariate analysis. Nevertheless, the authors state SHS is an important public health problem in Slovakia, and more public health activities in children protection from tobacco smoke in the family and household smoking bans are needed[37].

Another important and highly topical issue is the problem of alternative tobacco products, like water pipes, heated tobacco, e-cigarettes, and their possible health effects and contribution to SHS[17]. In the United States, the prevalence of current cigarette smoking among adults has declined from 42% in 1965 to 20.9% (nearly 21 of every 100 adults) in 2005 to 11.5% (nearly 12 of every 100 adults) in 2021[55,56]. Cigarette use has dramatically decreased in recent years; however, there has been an increase in adolescent and young adult use of alternative tobacco products (ATPs). E-cigarette use increased, from 3.7% to 4.5%, largely driven by higher prevalence in use among persons aged 18–24 years[56]. In 2021, an estimated 46 million U.S. adults (18.7%) reported currently using any tobacco product, including cigarettes (11.5%), e-

cigarettes (4.5%), cigars (3.5%), smokeless tobacco (2.1%), and pipes (including hookah) (0.9%)[56]. E-cigarettes are sometimes called "e-cigs," "vapes," "e-hookahs," "vape pens," and "electronic nicotine delivery systems (ENDS)." E-cigarettes produce an aerosol by heating a liquid that usually contains nicotine—the addictive drug in regular cigarettes, cigars, and other tobacco products—flavorings, and other chemicals that help to make the aerosol. Users inhale this aerosol into their lungs. Bystanders can also breathe in this aerosol when the user exhales into the air. Using an e-cigarette is sometimes called "vaping." The e-cigarette aerosol that users breathe from the device and exhale can contain harmful and potentially harmful substances, including nicotine, ultrafine particles that can be inhaled deep into the lungs, flavoring such as diacetyl, a chemical linked to serious lung disease, volatile organic compounds, cancer-causing chemicals, and heavy metals such as nickel, tin, and lead. Vaping is fundamentally different from smoking because it involves the heating of an e-liquid that doesn't contain tobacco, while smoking involves the combustion of tobacco. The National Academy of Sciences, Engineering, and Medicine 2018 released a report stating that while ECs are not without health risks, they are likely to be far less harmful than conventional cigarettes and can help adults to stop smoking[57]. The systematic review suggests that EC use may help to reduce the number of smoked cigarettes as well as to relieve nicotine withdrawal symptoms[58]. There is substantial evidence among youth (who use ECs at higher rates than adults) that EC use increases the risk of transition to the smoking of conventional cigarettes[57].

Hookah is perceived as a safer and less addictive alternative to cigarettes, despite multiple studies that show that hookah smoke is potentially more harmful than cigarette smoke. Smokeless tobacco is another alternative tobacco product that is consumed orally and includes chewing tobacco and oral snuff. The negative health implications of these products include oral

leukoplakia, gingival recession, cancer, cardiovascular disease, peripheral vascular disease, hypertension, peptic ulcers, and increased rates of fetal morbidity and mortality[10,59].

IQOS, or heated tobacco products heat processed tobacco leaves, allowing users to inhale nicotine into their lungs. Heated tobacco products are still new and scientists are still learning about their short-and long-term health effects. However, the use of any tobacco product, including heated tobacco products, is harmful, especially for youth, young adults, and pregnant women, as well as adults who do not currently use tobacco products[55].

Intervention possibilities

The most effective public health intervention to reduce SHS exposure is to implement and enforce smoke-free workplace policies that protect entire populations including all workers regardless of occupation, race/ethnicity, gender, age, and socioeconomic status[60].

Non-smokers need to be protected from second-hand smoke exposure within the home, at school, and in the workplace. Women and children often do not have the power to negotiate smoke-free spaces, even within their own homes. Some workers are obliged to spend most of their work time in a health-threatening environment.

Protection can be achieved through smoking bans and by smokers taking responsibility for not exposing others to their second-hand smoke. Smoke-free legislation is very popular wherever it is enacted, with support for tobacco control measures usually increasing after implementation. Smoke-free workplaces help to motivate smokers to quit smoking and reduce tobacco consumption by 4%–10%. Smoke-free policies also help prevent people, especially the young, from starting to smoke[61].

The tobacco industry has tried to argue that smoking bans infringe on smokers' rights and freedom of choice, but no one has the right to harm others. Smoke-free laws do not infringe on anyone's rights and are simply there to protect people's health by regulating where to smoke and where not to smoke. Article 8 of the WHO Framework Convention on Tobacco Control addresses protection from exposure to tobacco smoke. It stipulates that all people need to be protected from second-hand smoke through the adoption and implementation of legislative and other measures to provide protection from exposure to tobacco smoke in indoor workplaces, public places, and public transport[61].

It is important to remember the following:

There is no safe level of exposure to second-hand smoke.

Non-smokers, including women and children, have a right to breathe tobacco-free clean air.

Ventilation or designated smoking rooms do not offer effective protection.

All indoor workplaces, public transport, schools, and health services should be smoke-free.

People need to be better informed of the hazards of second-hand smoke to themselves, fetuses, children, and other family members.

Conclusion

This narrative review presents recent research concerning SHS and its unfavorable associations with the physical and mental health of vulnerable population groups (women, pregnant women, children, adolescents, and young adults). Full papers in the English language were searched in the PubMed, Google Scholar, and Web of Science databases as well as the US Surgeon General's Reports, WHO, and CDC documents and statements. Special attention was paid to studies based on the bilateral American-Slovak project

"Prenatal, pregnancy and childhood exposures to household smoking and their relations to subsequent development and health in Slovakia". The research on SHS and health effects help in campaigns for smoke-free environments and in the promotion of community-based smoke-free programs. Besides school and workplace, a complete smoking ban at home should be considered to avoid potential adverse health effects on vulnerable population groups.

Conflict of Interest

The author declares no conflict of interest.

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