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Research Progress on Epidemiology and Comprehensive Prevention and Control Strategies of HIV Infection

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Abstract: Acquired Immunodeficiency Syndrome (AIDS) caused by Human Immunodeficiency Virus (HIV) infection poses a serious threat to global public health. This article comprehensively reviews the epidemiological characteristics of HIV infection, including the global and domestic epidemic situation, transmission routes, and characteristics of high-risk groups. It also introduces comprehensive prevention and control strategies in detail. Through analysis, it aims to provide a reference for further optimizing HIV prevention and control work.

Keywords: HIV infection; Epidemiology; Prevention and control strategies

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1. Introduction

AIDS is an infectious disease caused by the Human Immunodeficiency Virus (HIV), which has a significant impact on society. It not only severely damages the health of patients, leading to the collapse of the immune system and triggering various opportunistic infections and tumors, but also greatly reduces the quality of life of patients and shortens life expectancy. In addition, it brings a heavy socioeconomic burden, including medical expenses, labor loss, and impact on family and social stability. As time goes by, the epidemiological characteristics of HIV infection are constantly changing, such as the change in the proportion of transmission routes and the expansion of high-risk groups, which puts forward continuous and higher requirements for prevention and control work. In-depth study of the epidemiology and comprehensive prevention and control strategies of HIV infection is extremely important to effectively contain the spread of the epidemic, improve patient prognosis, and reduce the socioeconomic burden.

2. Epidemiological characteristics of HIV infection

2.1. Global epidemic situation

2.1.1. Number of infections and geographical distribution

In 2023, according to a report by UNAIDS, approximately 40 million people worldwide are currently infected with HIV. The geographical distribution is extremely uneven, with Sub-Saharan Africa remaining the hardest hit region, accounting for nearly 70% of global infections. For example, in South Africa, according to local health department data, as of 2024, approximately 7.8 million people are infected with HIV, with an infection rate of 12.6%. This is mainly attributed to factors such as relatively open sexual attitudes in the region, high prevalence of sexually transmitted diseases, lack of medical and health resources, and weak awareness of HIV prevention and control among some people [1]. The number of infections in Asia cannot be ignored. India has about 2.3 million HIV-infected people. Due to its large population base, poor sanitary conditions in some areas, and the lack of protection for sex workers, the number of infections remains at a relatively high level.

2.1.2. Changes in epidemic trends

In recent years, the number of new HIV infections globally has shown a downward trend overall, but the situation is not optimistic in some regions. Due to the large scale of injecting drug users and the widespread phenomenon of sharing needles, coupled with the imperfect health service system during the socio-economic transition, the epidemic is on the rise in Eastern Europe and Central Asia. According to data from the European Centre for Disease Prevention and Control, the number of new infections in some countries in the region increased by 15% to 20% compared with the same period last year in 2024. However, the number of AIDS-related deaths globally has declined, thanks to the promotion and popularization of Highly Active Antiretroviral Therapy (HAART), which has enabled patients' immune systems to be rebuilt, reducing the risk of death from opportunistic infections and tumors.

2.2. Current epidemiological situation in China

2.2.1. Overall infection situation

The number of HIV infections in China is continuously increasing, but the growth rate has slowed down. As of the end of 2023, there were approximately 1.29 million reported HIV infections in China, with about 110,000 new AIDS patients in 2023. The epidemic situation varies significantly in different regions, with relatively higher prevalence in southwestern regions such as Yunnan, Guangxi, and Sichuan. Taking Yunnan as an example, its location along drug smuggling routes and large population of injecting drug users, coupled with frequent personnel mobility in border areas and increased risk of sexual transmission, have made the province one of the leading regions in China for HIV infections [2].

2.2.2. Population distribution characteristics

From the perspective of age distribution, sexually active individuals aged 15–49 are the main infected group, but in recent years, the number of infections among elderly and adolescent populations has gradually increased. Among the elderly, some lack knowledge about sexual health and have a weak awareness of condom use, making them susceptible to HIV infection during sexual activities such as "twilight romances. [3]" Adolescents, on the other hand, have open sexual attitudes but inadequate self-protection abilities, especially in complex social environments around schools and online, leading to an increased risk of infection. Regarding gender, there are more male

infections than female, and the infection rate among men who have sex with men (MSM) has risen significantly. In some cities in 2024, the HIV infection rate among MSM reached 10%–15%. Occupations are widely distributed, including workers, farmers, students, and business service personnel. High-risk groups such as MSM, people who inject drugs (PWID), and sex workers remain the focus of prevention and control.

2.3. Analysis of transmission routes

2.3.1. Sexual transmission

Sexual transmission has become the primary route of HIV infection globally and in China. Worldwide, sexual transmission accounts for over 70% of new infections. In China, this proportion continues to rise, currently reaching about 90%. Heterosexual transmission used to dominate in China, mainly due to multiple sexual partners, extramarital sex, and low condom usage rates [4]. As social attitudes change, sexual transmission among MSM is rapidly increasing. This group engages in special sexual behaviors, frequently changes sexual partners, and generally has a lower condom usage rate than the heterosexual population. Some surveys indicate that condom usage among MSM is only 30%–50% [5]. Additionally, sexually transmitted infections (STI) such as syphilis and gonorrhea commonly coexist with HIV. STI-induced genital mucosal damage can increase the risk of HIV infection by 2–5 times [6].

2.3.2. Blood transmission

Treponema pallidum and *Neisseria gonorrhoeae* can survive in the blood, so unsterilized needles and blood products (such as blood collection or transfusion) can cause infection. *Treponema pallidum* is easily transmitted through tiny breaks in the skin or mucous membranes, typically through unprotected sex or sharing needles for drug injection. *Neisseria gonorrhoeae* can be transmitted through contaminated syringes, needles, and other medical equipment, as well as through blood, but due to its low infection rate and most people's immunity to it, it is not currently considered a route of HIV transmission [7].

2.3.3. Mother-to-child transmission

Mother-to-child transmission includes intrauterine infection, transmission during childbirth, and breastfeeding. Without intervention, the probability of mother-to-child transmission can reach 15%–45%. Through the implementation of the Prevention of Mother-to-Child Transmission (PMTCT) program, such as HIV testing for pregnant women, providing antiviral drugs to infected pregnant women for blocking treatment, choosing safe delivery methods (such as cesarean section to reduce the risk of transmission during childbirth), and guiding artificial feeding to replace breastfeeding, the mother-to-child transmission rate in China has dropped to below 2% [8]. However, in some remote areas, due to scarce medical resources, untimely prenatal care for pregnant women, and low awareness and participation in the PMTCT program, the risk of mother-to-child transmission still exists.

2.4. Characteristics of high-risk groups

2.4.1. Men who have sex with men (MSM)

The HIV infection rate among MSM is much higher than that of the general population, with infection rates reaching 10%–15% in some cities. They are sexually active, and according to surveys, some MSM have an average of 5–10 or more sexual partners. Additionally, there are high-risk behaviors such as multiple sexual

partners and group sex, which occasionally occur in some MSM social venues [9, 10]. Although awareness of HIV infection has increased among this group, some still have insufficient understanding of the risks of infection. Coupled with social discrimination and pressure, they are afraid to actively seek testing and treatment services after engaging in high-risk behaviors, increasing the risk of HIV transmission within the group and to other populations [11].

2.4.2. People who inject drugs (PWID)

PWID are highly susceptible to HIV transmission due to sharing syringes, needles, and other equipment. Drug addiction makes it difficult for them to abandon high-risk behaviors, and the high mobility of this group, often gathering in hidden places to use drugs, coupled with poor living and sanitary conditions, increases the difficulty of prevention and control. Some drug users also engage in promiscuous sexual behaviors to obtain drugs or money, further increasing the risk of HIV transmission. In some areas with severe drug problems, the HIV infection rate among PWID can reach up to 50%–80%, making them a significant source of HIV transmission in the local area [12].

2.4.3. Sex workers and their clients

Due to the occupational characteristics of sex workers, they frequently engage in sexual behavior with different sexual partners. If effective protective measures are not taken, the risk of HIV infection is extremely high. According to surveys in some areas, the condom usage rate among sex workers ranges from 60% to 80%, but there are still some who do not use condoms correctly due to client demands or their own lack of health awareness [13]. Their client group comes from a wide range of ages and occupations, and because of sexual contact with sex workers, they become a potential group for HIV infection. Moreover, this group often has a weak sense of health, lacks regular physical examinations and access to reproductive health services, which makes the risk of HIV transmission among this group and related populations persistent.

3. Comprehensive prevention and control strategies for HIV infection

3.1. Strengthen education and behavioral intervention

Through various channels such as television, radio, the internet, and social media, conduct HIV prevention and treatment publicity for the general public to enable them to have a correct understanding of their own physical condition [14]. For example, on platforms such as Weibo and Douyin, the click-through rate for HIV prevention themes has reached billions. Short videos and science articles are used to widely promote the transmission routes of HIV, the importance of prevention and testing. In primary and secondary schools, knowledge about HIV prevention should be integrated into health education courses. Starting from junior high school, various methods such as classroom teaching, thematic class meetings, and knowledge competitions should be used to strengthen adolescents' understanding. In communities, personalized publicity should be provided for residents of all ages through the distribution of promotional materials and lectures, reaching deep into community squares and residential areas [15]. For the MSM population, the role of peers in the group should be utilized to promote condom use, carry out offline communication activities, share experiences in AIDS prevention and treatment, and provide services such as AIDS screening and counseling [16]. Provide methadone maintenance therapy for PWID to reduce their dependence on drugs and reduce high-risk behaviors caused by drug abuse.

3.2. Universal HIV testing and diagnostic services

HIV detection technology has evolved from the initial Enzyme-Linked Immunosorbent Assay (ELISA) and Western Blot (WB) to rapid detection reagents and nucleic acid testing [17]. Rapid detection reagent methods are simple and easy to use, with results available in 15–20 minutes, making them suitable for testing in community screenings and primary medical institutions [18]. Nucleic acid testing can shorten the window period to 1–2 weeks, thereby improving the early diagnosis rate of the disease and laying the foundation for timely treatment of patients [19]. Testing sites are set up in large hospitals, disease control and prevention centers, community health service centers, and Voluntary Counseling and Testing (VCT) facilities, providing testing at low or no cost. At the same time, active testing in medical institutions is carried out, routinely screening hospitalized patients, surgical patients, and patients in STD clinics for HIV. Community mobilization testing encourages individuals with high-risk behaviors to actively seek testing through community organizations and volunteer promotions. In recent years, self-testing has been promoted, with testing reagents sold through internet platforms and pharmacies, allowing users to test themselves at home. After testing, online counseling services are provided to guide result interpretation and follow-up treatment, greatly improving testing convenience and promoting early detection and diagnosis.

3.3. Initiation of treatment and care support

HIV treatment primarily involves symptomatic management and antiretroviral therapy, typically commencing within the first three months after HIV infection. Since most patients cannot adhere to the complete drug regimen, and adverse drug reactions often affect patients' quality of life, researchers have continuously updated various antiretroviral drug combination regimens, such as the combined use of nucleoside and non-nucleoside drugs, long-acting and short-acting formulations, to improve efficacy, reduce toxic side effects, and enhance adherence. Currently, there are multiple validated effective treatment options available [20].

In recent years, with the emergence of new antiretroviral drugs, monotherapy or dual therapy has become an important choice for HIV treatment. Currently, various single-drug and two-drug combination regimens have been approved for the treatment of HIV/AIDS. For patients who cannot tolerate the adverse reactions of traditional regimens, novel multidrug combination therapy may be the best option [21]. However, this approach carries a higher risk of drug resistance, requiring individualized treatment strategies based on each patient's condition. Simultaneously, increasing evidence suggests that implementing immune reconstitution therapy early in treatment can prevent AIDS-related complications. Therefore, besides antiretroviral therapy, it is also necessary to consider how to restore human immunity through comprehensive means, including regulating bodily functions, enhancing antiviral capabilities, and stimulating the human immune system.

4. Conclusion

The epidemiological characteristics of HIV infection are complex and constantly changing. Although global and domestic prevention and control efforts have achieved certain results, there are still many challenges, such as virus variation and drug resistance, difficulties in preventing and controlling high-risk populations, and social discrimination. In the future, it is necessary to continuously strengthen multi-sectoral collaboration and social participation to jointly address HIV infection as a global public health issue, striving to reduce HIV infection rates, alleviate the burden of disease, and promote harmonious social development.

Disclosure statement

The author declares no conflict of interest.

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