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(REVIEW ARTICLE)

Epidemiology of Cytomegalovirus (CMV) from 2020 to 2025: Trends, Challenges and Future Directions, A Review

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Abstract

Cytomegalovirus (CMV) is the most common cause of congenital viruses and is a major global health problem. This review discusses the epidemiology of CMV, clinical effect and the existing diagnostic and treatment dilemma. The ubiquitous nature of CMV and its complicated transmission patterns are discussed, but the emphasis is put especially on the impact of CMV on the vulnerable populations such as pregnant women, neonates, and immunocompromised patients. The review explains the difference in seroprevalence and incidence across the world, and that although developed nations tend to have lower levels, the semi-developed nations have an increased transmission to deal with as a result of environmental and social dynamics. The recent literature (202025) has highlighted the impact of the sophisticated diagnostic technologies and the COVID-19 pandemic on CMV detection and management. Nevertheless, the current methods of diagnosis and treatment options have some drawbacks, which means that the use of better molecular diagnostics and specific antiviral treatment should be considered. Future studies must aim at interdisciplinary studies and improved surveillance to be able to know more about CMV epidemiologic patterns and also to establish effective methods to reduce its health impact on the world.

Keyword: Cytomegalovirus; COVID-19; Epidemiology; Global health

1 Introduction

Cytomegalovirus (CMV) is generally accepted as the most prevalent congenital pathogen, which is a serious health issue of the general population. The changes in the transmission rates, as well as the incidence of symptomatic diseases at the level of the population and, in particular, during pregnancy, make it hard to conduct epidemiological evaluation. This creates a continuous debate on the demographical trends of CMV infection and the related illness that might result. The discussion that follows fully provokes CMV using an epidemiological view of the subject in a way that demonstrates the complexities and challenges inherent in understanding its impact on maternal and fetal wellbeing [1,2].

The ubiquitous status of CMV presents a situation of relevance to a public health context to all countries, all groups of people and all ages, even though its cross-cutting effects have different policy and intervention implications [3,4,5]. For instance, CMV is primarily associated with neurodevelopmental impacts in children when congenitally acquired, with hearing loss as a result of multisystem disease associated with congenitally acquired CMV in children and cancer patients [6]. Realized nations worldwide indicate that surveillance studies must be adapted to capture this shift. To develop and support these surveillance studies, this article sets out objectives for 2025 aimed at rectifying gaps in our CMV epidemiologic knowledge base [7,8].

CMV is also proving its protean infectious capability alongside ongoing major global health challenges: it is a cofactor in human immunodeficiency virus progression and a significant infection for organ transplant and bone marrow transplant patients, while other emerging issues are heavily influenced by communication between congenitally

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infected infants and a slew of temporary caregivers, likely including care providers and preschool instructors [9,10,11]. In the context of widespread vaccination during the pandemic, pediatric prevention is supposed to take on an added set of incentives and challenges that would be tied to the degree of existing protection in the adult population [12,13].

1.1 Background of Cytomegalovirus (CMV)

Cytomegalovirus (CMV) is a member of the human herpesvirus family and is a ubiquitous virus that causes widespread immunological imprinting. It is the leading cause of nongenetic deafness and linear growth defects in children and is the most common congenital viral infection [14]. It is a significant cause of adverse pregnancy outcomes and congenital abnormalities. After primary infection of children and adults, complications of CMV infection can include encephalitis, mononucleosis-like diseases, Bell's palsy, cytopenia, hepatitis, pneumonia, and death [15]. Like all herpesviruses, CMV establishes latency after primary infection and can reactivate spontaneously or be reactivated in the context of a nascent or transient immunocompromised state or following interventions such as hematopoietic stem cell or solid organ transplantation in which patients are given immunosuppressive drugs [16]. Besides recipients of hematopoietic cell transplants and solid organ transplants, additional groups show significantly higher rates of primary CMV infections or reactivation [17]. These encompass individuals infected with HIV who have rogressed to advanced disease stages, those residing in nursing homes or long-term care institutions, those living in underprivileged communities with high rates of infection, and a subset of patients with chronic maladies, including both autoimmune diseases and diabetes mellitus, who require immunosuppressive therapy. An increase in the risk of CMV-associated sequelae is associated with immune system imbalances (e.g., T cell exhaustion, CD4 lymphopenia, and low CD4/CD8 ratios). In all of these groups, CMV may contribute to ongoing morbidity and mortality [18,19]. In some cases, CMV may affect the safety of some vaccines and vaccine efficacy by causing primary vaccine failure, and thus compromise the health security of the population. Even in immunocompetent children and pregnant women, diagnosis of active CMV infection or CMV disease is followed by additional medical evaluations and interventions, creating a burden on the health system [20,21,22,23].

2 Epidemiology of CMV

CMV infections are widely distributed across populations and typically follow a time dependent pattern such as age-specific seroprevalence [24]. The following sections will discuss CMV epidemiology with reference to five indicators (prevalence, incidence, at-birth prevalence rate, congenital, and sero-incidence) and their implications as surrogates of infection in different demographics as well as the predictability (and limits) of CMV infection in the population [25]. At the global level, CMV is one of the most prevalent infections in all populations of the world, and two parameters are extensively used to describe CMV epidemiology: seroprevalence and time of acquisition [26,27,28].

One of the main findings with respect to the most recent epidemiological data includes stable or decreasing rates in some areas when compared to historical data, suggesting minor changes in transmission routes of CMV or population infection dynamics [29]. Additionally, several studies underline the significant variation in some studies when compared to the average rate for each continent, suggesting that local habits and policy in public health may play a critical role in the success of infection control [30]. Indeed, the global situation presents several demographic patterns across different areas and countries, with at-birth seroprevalence (congenitally acquired CMV at birth) lower than 50% mainly in developed countries as a consequence of several environmental factors, including a combination of both amniotic CMV passage and vertical transmission from the mother. Such values reach about 50–60% in some semi-developed countries after high values of transmission due to socialization in the preschool period [31,32].

2.1 Global Burden of CMV Infections

Cytomegalovirus (CMV), a species in the Herpesviridae family infects a major percentage of the population worldwide and has a huge contribution to the various types of morbidity. Its deep impact is explained by taking a closer look at the health consequences of CMV and the health system and population financial consequences [33]. The humanitarian issue of the effect of CMV on low-resource environments particularly where medical care is unavailable is a serious challenge. Pediatric populations and adult populations worldwide report high seroprevalence of CMV, which is a major challenge to the health of the population. This is especially true of infants and young children where most of the infections result in abortuses, stillbirths and congenital CMV infections, which further complicate the implication of such cases to the families and communities [34].

Prevalences vary from as low as 30% in individuals under 18 in Kiribati to 92% of children 12–23 months in Vietnam. CMV-related health sequelae, particularly sensorineural and neurological deficits, contribute an immense health burden. As many as 15 human organs or organ systems can be affected by congenital CMV, ranging from negative audiological sequelae to constitutional symptoms and neurological compromise. With the still widely accepted ongoing sequelae-crisis model, the true health implications of this virus are unknown until children age [35,36]. Acute infection

can follow for life and is a recurrent cause of morbidity for many children, increasing the risk of miscarriage and chances of lifelong neurological complications. Studies highlight the broader public health significance of CMV: up to 8,000 infants are victims of symptomatic congenital CMV annually, while as many as 3,600 deaths or unknown deaths can occur in neonates with congenital CMV disease [37,38,39].

2.2 Prevalence and Incidence Rates

The most recent epidemiological investigations calculated the prevalence of CMV IgG antibodies and/or CMV active infection in several groups. A systematic review reported a worldwide CMV IgG prevalence that ranges from 30% in 1- to 6-year-old children and adolescents with low-risk exposure to over 95% in military personnel and midwives, in healthcare and community workers, and in blood donors [40]. A prevalence of viremia that ranges from 0% in children aged 1 month to 11 years with a negative CMV serology who undergo transplantation to 94.5% in women of childbearing age, patients at the end stage of renal diseases, and vertically infected children was also noted [41].

Prevalence studies have also been conducted in several community-based cohorts that cover all geographical regions. Specific prevalence rates from studies among blood donors, pregnant women, postpartum women, and children in Uganda were 83.4%, 50.0%, 77.5%, and 1% at birth and 40% by the age of 4 months in 2010, and 2 years, respectively [42,43]. Awareness and proper screening and detection are key factors that influence CMV prevalence estimates. During the past 5 years, cross-sectional surveys among women of childbearing age, pregnant women, and HIV-infected persons living in the Russian Federation, as well as blood donors, reported point prevalence, i.e., the percentage of people with an ongoing infection at study inclusion, ranging from 3.8% to 7.1% [44,45]. The incidence rate is estimated for a defined time period and is highly dependent on the population's health status, childbirth rates, and antiviral interventions [46,47].

3 Trends in CMV Epidemiology

At the time of this research, several findings regarding the pandemic's impact on cytomegalovirus (CMV) epidemiology were reported, focusing on local and national trends and public health responses [48,49]. These included changes in CMV seroprevalence, prevalence, incidence, and vertical transmission control [50,51]. Studies confirmed the rising use of sensitive diagnostic methods and evaluated their influence on clinical management policies [52,53].

The findings showed that CMV infections were similar in the first year for both intervention and control groups, consistent with previous studies. As CMV trends shift with diagnostic advancements and epidemic responses, long-term monitoring is crucial to identify new epidemiological patterns [54,55]. Effective public health measures require careful evaluation before rollout, making initial surveys necessary for timely assessments [56,57]. Ongoing studies of the same cohort can track incidence and provide important diagnostics over time [58,59].

3.1 Key Findings from 2020-2025 Studies

Several characteristics related to the epidemiology of CMV have emerged, evolved, or become further elucidated, allowing the ability to inform some future CMV studies and policies. Studies published during this five-year window have bolstered some aspects of CMV awareness, demonstrated the use of new technologies to evaluate the public health burden of CMV, and reinforced what is known about the protectiveness of CMV serostatus and quantitative assessment of antibodies [60,61]. Further, studies from 2020 to 2025 have clarified some CMV-related morbidities. Work from the past five years has also provided information on the evolving trend of CMV in the population. This summary will focus on presenting information in the studies' most basic form, although further details and discussion can be found within the following sections [62,63,64].

4 Challenges in CMV Research

CMV epidemiological studies are in a stalemate, particularly in the developing nations where the diagnosis is constrained thereby undermining the reporting and control of the cases, further exerting risks to the epidemic. It is necessary to update the management plans and laboratory diagnostics in blood banks and in cases of congenital [65,66]. Investments should focus on the state of the art diagnostics and increase antiviral therapy to immunosuppressive patients. CMV research also has operational challenges including testing and issues of ethics which misappropriate the resources. A shortage of funds demands restructuring, and the COVID-19 pandemic has brought new attention to CMV research [67,68].

4.1 Diagnostic Limitations

Management and detection of cytomegalovirus (CMV) infection depends on diagnostic tests that are not usually optimal in terms of either sensitivity or specificity. Poor timing may result in false negative, particularly with high-risk patients [69,70]. CMV can either cause typical symptom or remain silent and postpone the diagnosis and treatment of immunocompromised patients. It is important to improve diagnostic procedures and timing in order to detect asymptomatic cases. The necessity of standardization of the tests is one of the most important aspects of effective healthcare, and the training of the lab staff guarantees the quality of the results [71,72,73]. Richer laboratories could offer better facilities which poorer areas are not able to afford and a timely treatment cannot be done. Finding validation and creating awareness among patients is essential toward the better [74,75,76].

4.2 Treatment Gaps

Fears with regard to traditional CMV therapies disclose an absence of care. Existing antiviral treatments have the ability to extend and reduce symptoms but they can only effectively attack a small fraction of the virus [77]. Even though oral and IV option has its advantages, its use is limited by side effects such as cytopenia, rare reactions, and antiviral resistance. Although AAP-approved treatments are beneficial to some patients, not all of them require medication, unless necessary, taking into account CMV risks in transplant groups [78,79]. The use of treatments requires compliance based on safety, dosing convenience and laws. There are insufficient guidelines, which dispute the acceptance of medication and management of resistance, and insufficient data on trends of resistance is available [80,81,82].

5 Future Directions and Research Opportunities

Researchers studying cytomegalovirus (CMV) face stagnation in breakthroughs amid a pandemic, requiring new strategies for diverse disease patterns [83,84]. Epidemiology will direct CMV research, focusing on passive surveillance and addressing disparities in congenital and perinatal cases, especially in vulnerable groups like HIV patients [85,86]. Gaining a comprehensive understanding of pathogens, paired with new tools, including molecular diagnostics, could inform CMV research into novel strategies to diagnose and monitor disease occurrence. Many epidemiological studies are left to be done. Work in interdisciplinary research fosters further research [87,88].

5.1 Emerging Technologies and Innovations

Advancements in molecular diagnostics are revolutionizing CMV research with PCR-based tests delivering quicker results that aid pregnant women and stem cell studies [89,90]. These advances will result in a much deeper understanding of CMV evolution, and consequently, a much better way to treat resistant strains with antiviral therapies. While a large amount of interest is currently being placed upon small-molecule antivirals, with lots of high-impact studies being done over the next five years that could extrapolate for many years to come, the remaining work on early immunotherapy could drag well into the latter parts of the 2020s [91,92]. Concerns are developing from the load generated by population data. Because it may have been a little bit understaffed for users in some instances, there has been an increase in users and the existing load may not have to be added and implemented, making it impossible to keep up. The pandemic has hampered the gradual advancement of telehealth, which could ultimately lead to poorer CMV results [93].

Conclusion

Cytomegalovirus (CMV) remains a major global public health concern because of its high seroprevalence, diverse transmission routes, and significant impact on vulnerable populations such as pregnant women, neonates, transplant recipients, and immunocompromised individuals. Studies published between 2020 and 2025 indicate that although the general epidemiological pattern of CMV infection remains relatively stable, important regional differences persist, particularly between developed and semi-developed countries where environmental, socioeconomic, and healthcare conditions influence transmission dynamics. Congenital CMV continues to contribute substantially to neonatal morbidity, hearing loss, and long-term neurological complications. Recent advances in molecular diagnostics, especially PCR-based detection and genomic analysis, have improved early identification and monitoring of infection, yet access to these technologies remains uneven in low-resource settings. Current antiviral therapies still play an important role in clinical management but are limited by toxicity, resistance, and incomplete long-term effectiveness. In addition, the post-pandemic healthcare context has emphasized the importance of stronger surveillance systems and adaptive infection-control strategies to maintain CMV screening and treatment continuity. Future progress will depend on strengthening epidemiological surveillance, expanding access to reliable diagnostics, improving preventive screening programs, and accelerating vaccine development through interdisciplinary collaboration involving virology, immunology, maternal health, and public health policy.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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