Towards the Elimination of Hepatitis C in the United States

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Abstract

The emergence of effective direct-acting antiviral (DAA) agents has reignited discussion over hepatitis C elimination potential in the United States. Eliminating hepatitis C will require a critical examination regarding technical feasibility, economic considerations, and social/political attention.

Tremendous advancement has been made in recent years with the availability of sensitive diagnostic tests and highly effective DAAs capable of achieving sustained viral response (SVR) in more than 95% of patients. Eliminating hepatitis C requires escalating existing surveillance networks to identify and respond to new epidemics. Basic prevention strategies such as community based outreach and education, testing and counseling, clean syringe and needle exchange programs, safe injection sites, opioid substitution therapies, and mental health services must be scaled up and adapted to target high risk groups.

Although costs of DAAs have raised budget concerns for hepatitis C elimination, studies have shown that eliminating hepatitis C will produce a savings of up to 6.5 billion USD annually along with other intangible benefits such as work productivity and quality of life. Simulation economic models and meta-analyses suggest that all adults should be screened for hepatitis C, but special efforts must focus on high risk populations.

There is growing recognition that social and political factors are at least as important as technical feasibility and economic considerations. Due to lack of promotion and public awareness, HCV elimination efforts continue to receive inadequate funding. Social stigma continues to impede meaningful policy changes. Eliminating hepatitis C from the U.S. is possible but it will require a sustained national commitment and strong political leadership.

Introduction

Chronic hepatitis C virus (HCV) is a major medical and public health concern. Across the globe, approximately 170 million people are believed to be infected (1). In the United States, the prevalence is approximately 2% with between 5 and 7 million Americans infected with HCV (2). Chronic hepatitis C is a systemic infection and an important factor in morbidity and mortality. Hepatitis C is one of the most common causes of cirrhosis, a risk factor for hepatocellular carcinoma, and an indicator for liver transplantation. Non-hepatic manifestations of HCV include insulin resistance, cryoglobulinemia, and renal disease (3). Infection of HCV is also associated with substantial health care utilization, with an estimated direct cost to be around 6 to 7 billion U.S. dollars annually in the U.S. alone (4,5). In addition, the cost of HCV extra-hepatic manifestations has been estimated to be 1.5 billion U.S. dollars in 2014 (6). Overall costs associated with HCV are believed to be even higher as current estimates do not include indirect costs of productivity (4).

The ultimate goal of public health is the eradication of diseases. Whereas eradication refers to the permanent infection incidence of zero throughout the world, elimination refers to an infection incidence of zero in a specific geographical area (7). Despite recent advances in medicine, smallpox remains the only human disease that has been confirmed to be eradicated globally by the World Health Organization (WHO) (8). Global efforts are currently underway for the eradication of other diseases such as polio, malaria, yaws and dracunculiasis (9). In the United States, in particular, several notifiable diseases such as polio and measles have been reported to be eliminated with vaccination playing an important role (10).

Criteria have been established to identify disease characteristics that are most likely to be candidates for eradication: technical feasibility, economic considerations, and social/political attention (Table 1) (7). Technical feasibility can be further defined by the accuracy of diagnostic tests and the role humans play in the life cycle of the infectious agent. The costs of treatment combined with the lack of infrastructure in developing countries pose as barriers for the global eradication of HCV. However, HCV may be a potential candidate for elimination in the United States. Unlike other infections whose efforts to achieve eradication and elimination have revolved around immunization, the treatment of established HCV infection includes the use of

direct-acting antiviral (DAA) agents. Our objective in this review is to ascertain the possibility of eliminating HCV using established public health qualifying criteria.

Methods

Search Strategy:

We used PubMed, GoogleScholar and ScienceDirect databases to conduct our search using a combination of the following keywords: 'Hepatitis C virus', 'eradication', 'elimination', 'prevention', 'control', 'economic burden', 'vaccination', 'direct antiviral agents', 'interferon free', 'treatment cost', 'cost effectiveness analysis', 'screening test sensitivity', 'global epidemiology', 'prevalence', 'incidence', 'transmission', 'social and political support', 'public awareness', 'non-human reservoir', 'syringe and needles', 'correctional facilities', and 'safe injection sites'. Identified studies' bibliographies were searched for additional studies. We only consider studies published after 1975. We also used figures and statistics from the Centers of Disease Control and Prevention (CDC) and the National Institute of Health (NIH).

Technical Feasibility

Technical feasibility is one of the three cardinal pillars believed necessary for disease elimination (Table 1). The criteria for technical feasibility include: having no non-human reservoir of the disease, a sensitive diagnostic test, and an effective intervention to prevent the transmission of disease (Table 2). Another criteria is having a strategy that has been tested in a geographical area and found to be effective (field-proven strategy) (7, 11). The following discussion will examine the technical feasibility of HCV using the above criteria.

Non-human Reservoir

The absence of a non-human reservoir is a favorable feature in favor of HCV elimination. When a pathogen cannot propagate outside of a human host, it becomes more vulnerable to focused

intervention and consequently, cannot reinfect humans through cross species transmission (12). Without a non-human reservoir, interventions against smallpox, including mass vaccination, surveillance and containment of infected individuals, were able to focus on human hosts and led to its eradication by 1980 (13,14). In contrast, besides treating infected humans, the global malaria eradication campaign required use of insecticides against mosquito vectors, and the effort ultimately failed once those vectors developed resistance to the insecticides, leading to resurgence of the disease in previously controlled areas (12,15).

Practical & Sensitive Diagnostic Tools

Disease elimination requires highly sensitive and specific diagnostic tests for diagnosis and surveillance. The standard screening test for HCV is an enzyme linked immunosorbent assay (ELISA) that detects anti-HCV antibodies. The third generation of this screening test has been reported to have sensitivity and specificity up to 97% and 100%, respectively (16). A positive antibody test is followed by HCV RNA testing via polymerase chain reaction that confirms an infection and quantifies the viral load. Both of these tests have been used widely for HCV diagnosis in many different health systems in developed countries (17). Point of care HCV testing using fingerstick blood such as OraQuick HCV Rapid Antibody Test manufactured by OraSure Technologies in Bethlehem, Pennsylvania, is also available and has comparable sensitivity and specificity to that of HCV ELISA test (18,19). Such tests may be helpful in screening large groups of individuals using limited resources (20).

While the diagnostic tests themselves are sensitive and specific, there is still room for improvement in utilizing these tests to increase case identification and link patients to specialized care. For instance, historically less than 20% of patients diagnosed with HCV were referred to treatment (21). To address this gap, the University of California Los Angeles Health has implemented electronic health record HCV screening reminders and utilized a non-clinically trained patient care coordinator to facilitate both follow up HCV RNA testing and linkage to care. After implementation of the program, HCV screening increased by 145% (17). HCV

antibody positive patients who received HCV RNA testing also increased from 83% to 95% (p <0.01), and the percentage of patients who attended their initial appointment with a specialist increased from 88% to 94%. The results of the study highlight the role of a coordinator to help bridge the gap from diagnosis to eventual potential treatment.

Bridging the gaps in our current HCV care cascade will also require clear targets to be successful. For HIV infection, the ambitious goal of 90% diagnosed, 90% on treatment, and 90% virally suppressed (90/90/90) has been proposed as a target that can potentially end the AIDS epidemic by 2030 while no such goal has been proposed for HCV (22). However, a mathematical model predicted that HCV will become a rare disease, defined as 1 in 1500 persons, by 2036 when assuming 90% of high risk individuals diagnosed, 80% accepted treatment, and 90% virally suppressed (90/80/90) (23,24). This 90/80/90 goal can potentially be used as a target for HCV elimination, although further study is needed to assess its true utility on HCV incidence.

Surveillance

Disease elimination also requires a surveillance program to allow us to fully grasp the scope of the current HCV epidemic and to monitor our progress. HCV surveillance in the United States has been established since 1982 but the program is chronically underfunded as only seven jurisdictions are funded by the CDC (25, 26). Additionally, local health departments are responsible for reporting to the CDC, and the data aggregation across different levels of government is not always accurate (26). HCV infection is also more prevalent among marginalized groups, such as the homeless, prisoners, and intravenous drug users (IVDU), who have little to no access to healthcare. As a result, estimating the true prevalence of HCV has been difficult. Using data reported on HCV prevalence among the aforementioned groups and the total population of each group, the most conservative estimation has put HCV prevalence in the U.S. at approximately 5.2 million cases, which is 1.5 million more than the prevalence reported by the National Health and Nutrition Examination Survey (NHANES) and the CDC (2). The results of this study highlight the need for additional community outreach programs to administer

screening tests among high risk populations along with the employment of a dedicated database for HCV surveillance (27).

Effective Intervention Tools

There are a number of tools to prevent and treat HCV. Injectable drug use is one of the most common modes of transmission of HCV. Consequently, clean syringe and needle exchange programs (SNPs) have been demonstrated to reduce HCV transmission rates among injectable drug users. A number of cities have shown up to a 29% reduction in HCV prevalence among IVDU respectively in over an almost 10-year period of time with needle exchange programs (28). HCV incidence among IVDU has fallen by 10 to 25% in the 1980s after SNPs were introduced for HIV prevention (27,29). Unfortunately, widespread use of SNPs is limited by insufficient funding. Current laws that restrict the sale of needles and syringes in pharmacies may also contribute to the spread of blood borne diseases (30).

Hepatitis C antibodies are not neutralizing and therefore patients with a history of HCV remain at risk of reinfection after they clear the initial viral infection. Opioid substitution therapy and mental health services may decrease the likelihood of reinfection. In a population based cohort study evaluating 5,915 patients with HCV, the overall reinfection rate in IVDU was 1.53 per 100 person-years (PY) (31). However, in IVDU who achieved SVR for initial infection, the reinfection incidence decreased to 1.14 and was even lower (0.84) for those who received opioid substitution therapy (OST) and mental health services (31). Currently, many medical services are still reluctant to treat IVDU due to concerns over non-adherence and reinfection risk but this data suggests that augmenting DAA treatment with OST and mental health services will prevent reinfection (32).

Prophylactic vaccination has played a crucial role in eliminating diseases (e.g. polio, smallpox, measles, and rubella), but such a vaccine is not yet available for HCV. There are multiple challenges towards developing a vaccine including high mutation rates, epitope shielding, and innate immunity signaling blockades (33). Although the lack of a non-human reservoir is a

favorable feature for elimination, this feature also prevents the use of suitable small animal models for vaccine candidate evaluation (33). Three vaccines are currently in clinical trials with a few others completed their phase one clinical trial without published results according to www.clinicaltrials.gov (34).

Over the past several years, there has been a paradigm shift in the treatment of HCV. Treatment initially consisted of interferon whose use was limited to only those patients with progressive liver disease due to the adverse effects of interferon regimens. The use of DAAs, however, has increased the pool of patients eligible for therapy. Current treatment with DAAs is not only highly effective, but also safe and tolerable (35). The current sustained viral response in patients with HCV is over 90% regardless of HCV genotype patients (27).

Besides achieving SVR in infected individuals, DAAs can also have a great impact in decreasing HCV transmission. Similar to the success of treatment-as-prevention strategy in HIV infection where antiretroviral therapy reduced the rate of transmission by 96%, scaling up HCV treatment with DAAs among IVDU has been predicted to lower HCV prevalence (36,37). Using a mathematical model, Martin et al have shown that by increasing the HCV treatment rate by 15, 40, and 76 treatments per 1000 IVDU per year we can achieve a 50% prevalence reduction in 15 years in Edinburg, UK; Melbourne, Australia; and Vancouver, Canada, respectively. The higher the chronic HCV prevalence, the greater the treatment scale up is required to achieve 50% prevalence reduction in 15 years (37).

Synergy with Other Interventions:

Synergy with other interventions refers to a public health initiative's ability to utilize existing infrastructures to implement its agenda. SNPs originally designed for HIV prevention also lowers the incidence of HCV (28). Integrating HCV and HIV counseling and testing (C&T) at community outreach programs increases the rate of disease screening significantly compared to

offering them separately (38). The emergency room has been proposed to be another possible point for screening where the addition of HCV screening did not increase the ER length of stay when there are other laboratory tests involved (39). The use of an electronic HCV screening reminder in existing electronic health medical records (EHR) has been shown to increase the number of screening tests by 145% in a large academic healthcare system (17). Family physicians and nurse practitioners are able to achieve similar SVR rate to a specialist's with DAAs after 3 hours of guideline based training (40). Both the Hepatitis C Therapeutic Registry and Research Network (HCV-TARGET) and the TRIO network reported equivalent SVR rate between community clinics, hospitals and clinical trials, suggesting that HCV treatment can be delivered effectively using existing community clinics and personnel (40,41,42).

Field-Proven Strategies

No health system has successfully eliminated HCV but there are a number of organized efforts that achieve initial success owning to establishing a national committee, having strong government support, and using a universal healthcare system. For instance, Georgia has become the first nation to launch a national campaign to eliminate HCV in 2015. From January 2015 to December 2016, several mass HCV screening programs were conducted in Georgia targeting high risk groups (e.g. IVDU, prisoners, HIV patients) and led to identifications of 50,962 HCV antibody positive individuals with 59% of those confirmed to have chronic HCV infection by PCR testing. Through partnership with the pharmaceutical industry, Georgia is able to offer DAA agents free of charge and increase the average monthly number of patients receiving treatment by 300% in 2016. Since the launch of the national campaign, the number of treatment centers have increased from 4 to 27 (43).

Another global example is Egypt, which has established more than 54 dedicated centers that manage approximately 800,000 chronic patients after forming the National Committee for Control of Viral Hepatitis (NCCVH). A national database was also established to monitor HCV elimination progress. Furthermore, NCCVH was able to negotiate with Gilead Sciences to

provide sofobuvir at a reduced price of $300 per bottle (compared to $28000 per bottle in the U.S.) (44,45).

Australia has made progress in eliminating HCV by initiating DAA treatment on 32,400 patients, a ten-fold increase from the previous year which also equates to 14% of total HCV patients nationally (46). There were two main factors contributing to this success. First, the Australian government invested 1.6 billion dollars to expand HCV treatment access to all affected adults and successfully negotiated lower DAA prices. Second, the medical community was able to increase the proportion of DAA treatment prescribed by general practitioner (GP) from 8% to 31%, and thus made treatments more accessible to patients (47).

In the U.S., the Veterans Affairs (VA) healthcare system has had relative success against HCV with 2.9 million patients (53% total VA patient population) screened for HCV and of those with HCV viremia, 39,388 patients (23%) initiated on treatment, which are higher than national average. High treatment cost continues to be a significant barrier in VA system and forces providers to prioritize patients for DAAs (48). HCV elimination in any of these three populations still requires significant expansion of their current operations, but these efforts will certainly present learning opportunities for other entities.

Effective Strategies

Hepatitis C elimination strategy requires effective utilization of all available interventions and coordinated efforts among government, industry and professional societies. All adults 20 to 69 years of age should receive at least one time HCV screening with special focus on high risk populations (49,50,51). Access to DAAs must be increased by negotiations between government and industry so treatment is available to all patients regardless of ability to pay. Public health infrastructure must be scaled up significantly to provide comprehensive care including SNP, OST, social support and mental health service. Community outreach programs must also be

scaled up to reach hidden populations namely homeless patients and IVDU. Large healthcare systems should consider incorporating patient coordinators to increase linkage between testing and care. Hospitals and clinics must aim to provide a safe and nonjudgmental environment to care for stigmatized populations and educate primary care providers in treating hepatitis C effectively (27).

Overall, technical feasibility favors HCV elimination with the lack of a non-human host, sensitive diagnostic tests, and potent interventions. Despite the lack of field-proven strategies, current efforts in Egypt, Georgia and Australia will provide valuable lessons in designing our own initiatives including establishing a national committee and a HCV surveillance program. Existing infrastructures can be used effectively but still require significant upgrade to match the scale of the HCV epidemic. The challenge remains to design social policy and clinical guidelines that will address the current gaps in HCV care cascade.

Economic Considerations

Any public health initiative must not only take into account technical feasibility but also economic considerations. HCV is a significant economic burden on the U.S. healthcare system. The cost of HCV is composed of direct costs (e.g. hospital admissions, medications, emergency rooms, doctor visits, blood tests, and rehabilitation center), indirect costs (e.g. patients' lost wages, family members' lost wages, employment and productivity) and impairment in patient-reported outcomes (PRO) such as health-related quality of life (HRQoL) (52). Total economic burden of HCV has been estimated to be around 6.5 billion USD annually with 1.5 billion USD from HCV extra-hepatic manifestations (4,6,53). This economic burden coupled with the high price of DAAs have raised concerns over health care budgets for HCV elimination. As a result, multiple investigators have evaluated the cost effectiveness of both screening and treating HCV.

Cost Effective Diagnostic Test

Several studies have demonstrated that universal screening for HCV is cost effective (49,50). Coffin et al. evaluated the cost effectiveness of a one-time HCV screening of U.S. individuals age 20 to 69 years to the current risk-based screening guidelines while assuming treatment strategy and cost based on 2011 AASLD guidelines (49,54). The simulation showed that recommending a one-time HCV screening in general population will be more cost effective than the current risked-based screening (49,54). Eckman at al. also concluded that the screening and treatment of any population with a prevalence above 0.84% is cost effective (50). A systematic review in 2016 suggested that HCV screening is cost effective in the general population, birth cohort of individuals born between 1945 and 1965 and among IVDU (51). These studies have suggested that recommending a one-time screening for HCV in the general population will be cost effective and enable us to fully grasp the magnitude of our current HCV endemic.

Correctional facilities offer another unique opportunity to screen a high prevalence HCV population (23.1 to 41.2%) that is institutionalized and more accessible compared to other groups such as homeless and IVDU (2). Using a simulation model, it has been shown that the U.S. health care system will save almost $700 million dollars in HCV-associated costs over 30 years if a one-time opt-out HCV screen is implemented in all state prisons for 5 years (55). According to a report by the Bureau of Justice Statistics, up to 80% of state prisons have HCV screening programs but only 8.6% of those programs were considered broad coverage despite HCV prevalence among inmates being at 17% (56, 57). More recently, a survey of 58 prisons and jails showed that the majority of HCV testing is either by inmate request or physician order; only five facilities have mandatory testing (58).

Cost Effective Treatment:

The treatment of HCV using DAAs has been shown to be cost-effective and even cost-saving, depending on the cost of drug therapy (59). In a systematic review, the median drug price threshold below which the treatment with first generation DAAs and second generation DAAs become *cost effective* were $120,100 and $227,200, respectively (59). The corresponding median drug price threshold below which the treatment with first generation DAAs and second

generation DAAs become *cost saving* were $11,700 and $70,900, respectively. These findings mean that second generation DAAs, average cost of $90,000, are very cost effective.

Although HCV treatment is cost-effective or even cost-saving, the up-front costs makes universal treatment impractical at the moment. A budget impact study revealed that depending on the estimate of HCV prevalence, total treatment cost using Sofosbuvir and Ledipasvir can range from $136 billion to $425 billion for prevalence between 1.6 to 5 million, respectively, using whole sale pricing (60). As a comparison, the U.S. federal government total healthcare spending was $3.2 trillion in 2016 while allocating approximately 26 billion dollars domestically for HIV with 20 billion dollars spending directly on HIV health services and medications (61, 62).

Intangible benefits

Besides improving clinical outcomes such as survival, achieving SVR in those infected will also have intangible benefits such as improvement of Patient Related Outcomes (PRO) (63, 64). The results of recent studies using interferon- and ribavirin-free regimen with DAAs have shown an increase in PRO scores, which represents quality of life, in all four validated questionnaires: the Short Form Health Survey, the Functional Assessment of Chronic Illness Therapy-Fatigue, the Chronic Liver Disease Questionnaire-HCV Version, and the Work Productivity and Activity Index: Specific Health Problem (52,65). This increase in PRO scores is observed in patients with and without cirrhosis (66).

Eliminating hepatitis C by treating those infected or preventing new infections produces savings in monetary values, an increase in productivity, and a reduction in mortality. Early SVR has been associated with a 74% reduction in all-cause mortality (67). Achieving early SVR also lowers the overall medical cost by 13 fold in the 5-year post-treatment period (68). These potential savings are especially meaningful as providing value based care has been the focus of national discussion in recent years due to an escalation in healthcare spending. Besides the obvious savings in direct cost (e.g. hospitalizations, medications, laboratory tests, and emergency services etc.),

eliminating HCV will also produce indirect savings (e.g. gained productivity, reducing social assistance spending) and other patient related outcomes such as emotional health and cognitive impairment. Additionally, many cost effective analyses have not taken into account the cost of preventing extra-hepatic manifestations of HCV which represents additional savings from HCV elimination.

Social and Political Attention

Social and political support are perhaps the most challenging aspects given the stigma associated with HCV patient populations. The availability of DAAs is encouraging but these interventions will only help patients with access to medical care while excluding the marginalized populations namely the incarcerated, injectable drug users and homeless patients. The HCV prevalence in these high risk populations has been estimated to be at least 22% while composing 42% of total cases in the US (2). Our current lack of political support and pervasive social stigma continue to pose significant barriers for interventions to reach the most vulnerable populations affected by HCV.

Social Support

Social stigma also impedes efforts to eliminate HCV by hindering public support for meaningful policy changes. Despite evidence that drug addiction is a chronic relapsing disease, drug use is almost always viewed as personal irresponsibility without accounting for underlying problems that led to drug addiction (69,70). As a result, HCV patients often face stigmatization in the healthcare and social settings (70,71). This stigma explains the recent opposition to safe injection sites initiatives by Boston city councilors despite evidence that these sites lower the risk of transmitting diseases by promoting safer injection techniques (72,73). Safe injection sites is a pragmatic step to contain healthcare cost, and it does not equate to endorsing drug use. Breaking this social stigma will require a coordinated efforts from public health organizations, professional societies, and medical school to educate both the public and providers (43).

Funding for HCV research has suffered from lack of promotion and public awareness. Despite HCV and HIV sharing similarities, HIV has acquired the status of being an “exceptional disease”

due to successful promotions and attracted much more funding (74). According to CDC data in 2014, HIV/AIDS prevalence is approximately 1.1 million with 8,300 deaths, while numbers for HCV indicate a prevalence 3.9 million, with 19,566 deaths (75,76,77). Data reported by the NIH showed that HCV received 111 million in funding while HIV/AIDS received 3 billion in funding despite the greater prevalence and mortality of HCV (Table 3) (77). This discrepancy is partly because HIV mostly affected men who have sex with men (MSM) who can advocate for themselves whereas HCV mostly affected IVDU who more likely end up in prisons and are unable to rally public support (78,79). Therefore, healthcare providers and social activists must intensify efforts to advocate for HCV elimination.

Political Support

Current law enforcement practices contribute to injectable drug users reluctance to disclose their drug use and access necessary preventive care. Strict regulations regarding the sale and distribution of clean needles and syringes from pharmacies continue to undermine public efforts to limit blood borne diseases (24). These policy changes must be the focus of any legislators and social advocates who support HCV elimination.

Technical consensus

In contrast to the challenges posed by the criminal justice system, HCV elimination in the U.S. gained the support of professional societies. In 2016, Nation Academy of Science, Engineering and Medicine (NASEM) published a national strategy report that identifies HCV and HBV as a significant threat to public health that must be addressed (79). This report explores the feasibility and barriers that must be overcome to eliminate HCV in the U.S. and has been sponsored by the Association for the Study of Liver Diseases (AASLD) (79, 80). Similarly, WHO published an advocacy brief highlighting the burden, the urgency and the estimated cost for hepatitis B and C elimination strategy in low and middle income countries (81).

Nevertheless, we have seen encouraging signs in the past decade. The California senate will vote on a legislation allowing supervised drug injection sites in the coming months and, if passed, the legislation will make California the first state to have such sites (82). Additionally, the CDC has designated May as Hepatitis C Awareness Month to encourage screening of high risk populations. Correctional facilities are an ideal setting to screen and educate a high HCV prevalence population, but this opportunity has been largely neglected; any intervention program in this population will be very impactful. Healthcare providers and social activists must continue to be proactive and advocate for necessary legislative changes such as relaxing harsh penalties for minor drug offense and eliminating restrictions on syringe and needle sales in pharmacies.

Conclusion

HCV elimination is technically feasible in the U.S. but continues to face multiple challenges and will require the collaboration of healthcare systems, pharmaceutical companies, social advocate and policy makers. The crucial first step is to establish an HCV elimination national committee to coordinate efforts from different sectors and levels of government. This national committee can advocate for the allocation of resources needed for surveillance database, SNPs, social safety networks, vaccine research, and initiatives to break down social stigma. Political leaders must spearhead meaningful policy changes. Government and pharmaceutical companies must start negotiations to lower drug prices for improved DAA access. Research continues to provide new insights on how to use our current technology cost effectively for HCV elimination. Multiple CEA supports general population HCV screening in addition to high risk population. Treatment with DAAs has been shown to be very cost effective even at the current price point. Vaccine development is making progress with three vaccines being in clinical trials.

Several countries have taken the first steps to address HCV infection through the creation nationwide treatment centers and available treatment. Domestically, the U.S. VA health system has had early success in screening and treating its patient population at a higher rate than general population. HCV elimination is an ambitious goal for any healthcare systems. However, with technological advances and existing infrastructures, the U.S. has the potential to become the first nation to eliminate HCV if we can secure sustained public support and political commitment.

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Table 1: Characteristics of Infection Elimination (7,12)

Characteristics
1. Technical Feasibility
Non-human reservoir
Practical & sensitive diagnostic tools
Surveillance programs
Effective intervention tools
Synergy with other interventions
Field-proven strategies
Effective strategy
2. Economic Considerations
Estimated direct economic burden
Estimated annual productivity loss savings
Cases averted per year
Cost effective diagnostic test
Cost effective treatment
Intangible benefits
3. Social & Political Attention
Social support
Political support
Technical consensus

Table 2. Feasibility of Hepatitis C Elimination in the United States*(7, 12)

Characteristics	Hepatitis C	Strength of Feasibility	Corrective Measure (s)
Technical Feasibility			
Non-human reservoir	No	↑↑↑	
Practical & sensitive diagnostic tools	Immunoassay	↑↑↑	
Surveillance programs	National surveillance system	↑	Increase federal funding; Increase community outreach programs; More accurate reporting by local health departments; Reflex RNA testing; Routine screening of homeless, prisoners, IVDU; offer screening to "baby boomer" population in urgent care clinics;
Effective intervention tools	DAAs, SNPs,	↑↑	Increase funding for SNPs; Risk-based screening; Case management; Decrease risk of reinfection after SVR; Expansion of the access to syringe exchange and opioid agonist therapy
Synergy with other interventions	Yes	↑↑↑	
Field-proven strategies	No	↑	Mass screening programs; Performance indicator/incentives
Effective strategy	Yes	↑↑	Free or low cost DAA; Overcoming insurance sobriety /abstinence from DAA restriction; Removing all restrictions to HCV treatment

Table 2. Feasibility of Hepatitis C Elimination in the United States (continued) *(7, 12)

Characteristics	Hepatitis C	Strength of Feasibility	Corrective Measure (s)
Economic Considerations			
Estimated direct economic burden of HCV	US $6.5 billion	↑	Increase HCV screening Treat regardless of fibrosis stage Increase access to DAAs
Estimated annual productivity loss savings	US $2.7 billion	↑	Remove all DAA restriction
Cases averted per year	18,626 cases	↑↑	
Cost effective diagnostic test	Yes	↑↑↑	
Cost effective treatment	Yes	↑↑↑	
Intangible benefits	Yes	↑↑	
Social & Political Attention			
Social support	Weak	↑	Break social stigma regarding HCV infection; Increase funding for HCV elimination
Political support	Weak	↑	Legislature changes for free access to preventative programs (i.e. SNPs**,** education programs on prevention of HCV spread)
Technical consensus	WHO, NASEM, AASLD/IDSA	↑↑↑	

*Abbreviations: DAAs= Direct-acting antiviral agents; SNPs=Syringe and needle exchange programs; IVDU=Intravenous drug users; HCV=Hepatitis C virus; WHO=World Health Organization; NASEM=National Academy of Sciences, Engineering, and Mathematics; AASLD/IDSA=American Association for the Study of Liver Diseases/Infectious Diseases Society of America

Table 3. Comparison of Prevalence, Mortality, and NIH Research Funding for Hepatitis C and HIV/AIDs in the United States*

Characteristic (source)	Disease	
	Hepatitis C	**HIV/AIDS**
Prevalence (75, 76)	2.7-3.9 million	1.1 million
Mortality (77)	19,566	8,300
NIH Research Funding (77)	$107 million	$3 billion

* Abbreviations: NIH= National Institute of Health; HIV=Human immunodeficiency virus; AIDS=Acquired immunodeficiency syndrome