Additional resource needs for viral hepatitis elimination through universal health coverage: projections in 67 low-income and middle-income countries, 2016–30

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Summary

Background The World Health Assembly calls for elimination of viral hepatitis as a public health threat by 2030 (ie, –90% incidence and –65% mortality). However, WHO's 2017 cost projections to achieve health-related Sustainable Development Goals did not include the resources needed for hepatitis testing and treatment. We aimed to estimate the incremental commodity cost of adding scaled up interventions for testing and treatment of hepatitis to WHO's investment scenarios.

Methods We added modelled costs for implementing WHO recommended hepatitis testing and treatment to the 2017 WHO cost projections. We quantified additional requirements for diagnostic tests, medicines, health workers' time, and programme support across 67 low-income and middle-income countries, from 2016–30. A progress scenario scaled up interventions and a more ambitious scenario was modelled to reach elimination by 2030. We used 2018 best available prices of diagnostics and generic medicines. We estimated total costs and the additional investment needed over the projection of the 2016 baseline cost.

Findings The 67 countries considered included 230 million people living with hepatitis B virus (HBV) and 52 million people living with hepatitis C virus (HCV; 90% and 73% of the world's total, respectively). Under the progress scenario, 3250 million people (2400 million for HBV and 850 million for HCV) would be tested and 58·2 million people (24·1 million for HBV and 34·1 million for HCV) would be treated (total additional cost US$ 27·1 billion). Under the ambitious scenario, 11 631 million people (5502 million for HBV and 6129 million for HCV) would be tested and 93·8 million people (32·2 million for HBV and 61·6 million for HCV) would be treated (total additional cost $58·7 billion), averting 4·5 million premature deaths and leading to a gain of 51·5 million healthy life-years by 2030. However, if affordable HCV medicines remained inaccessible in 13 countries where medicine patents are protected, the additional cost of the ambitious scenario would increase to $118 billion. Hepatitis elimination would account for a 1·5% increase to the WHO ambitious health-care strengthening scenario costs, avert an additional 4·6% premature deaths, and add an additional 9·6% healthy life-years from 2016–30.

Interpretation Access to affordable medicines in all countries will be key to reach hepatitis elimination. This study suggests that elimination is feasible in the context of universal health coverage. It points to commodities as key determinants for the overall price tag and to options for cost reduction strategies.

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Introduction

In 2015, viral hepatitis led to 1·34 million deaths globally.[1] Most viral hepatitis deaths are secondary to cirrhosis and hepatocellular carcinoma, which can be prevented with testing and treatment. In 2016, the World Health Assembly adopted elimination of viral hepatitis as a public health threat by 2030 (–90% incidence, –65% mortality).[2] Modelling work indicated that elimination could be achieved by reaching sufficient coverage for five core interventions.[3,4] These WHO recommended interventions are infant immunisation against hepatitis B,[5] prevention of mother-to-child transmission of hepatitis B virus (HBV) through timely hepatitis B birth dose vaccination and other approaches,[5] blood[6] and injection safety,[7] harm reduction for people who inject drugs,[8] and HBV and hepatitis C virus (HCV) testing[9] and treatment.[10,11] In 2016, preliminary cost estimates of viral hepatitis elimination were done by use of a programme-centred approach.[4] However, not all countries had been included

Research in context

Evidence before this study

In 2016, the World Health Assembly adopted the Global Health Sector Strategy for hepatitis that called for its elimination by 2030. To guide this resolution, WHO had commissioned an initial modelling study. However, this projection was done before WHO estimated the baseline for service coverage and did not use a universal health coverage perspective. In 2017, WHO costed the scaling up of universal health coverage to reach the health-related Sustainable Development Goals. However, it could not include hepatitis because the baseline indicators had not yet been established. Studies identified through a MEDLINE search using the search terms "hepatitis" and "elimination" and "(costing or financing)" for 2015–17 only identified country specific costing studies (eg, South Africa, Morocco, Thailand, and Australia).

Added value of this study

This work estimated the cost of scaling up interventions for the testing and treatment of hepatitis from the baseline to the elimination goals, within the perspective of universal health coverage and in the context of the Sustainable Development Goals. The results of the analysis suggest that hepatitis elimination is a high-impact intervention. The initiative would require an additional investment of 1·5%, but the effect would be proportionally higher, leading to a reduction of about 5% in mortality and an increase of about 10% in healthy life-years.

Implications of all the available evidence

The results of the analysis provide a quantified estimate of the resources needed for elimination of hepatitis by 2030 (in relation to the expected health impact), which can guide national and international stakeholders who have to make decisions in terms of financing. Overall, it suggests that elimination is feasible in the context of universal health coverage. It points to commodities as key determinants for the overall price tag and to options for cost reduction strategies.

and the estimates were made before WHO-validated baseline estimates, which were generated later in 2017.[1]

The concept of universal health coverage (UHC)[12] provides the logical framework to scale up these five core interventions. In 2017, WHO estimated that to advance towards the health targets of the Sustainable Development Goals (SDGs), low-income and middle-income countries would need to invest an additional US$3944 billion from 2016 to 2030 for an ambitious scenario, whereas a more modest progress scenario would require an additional $2929 billion.[13] The WHO SDG analysis addressed viral hepatitis prevention but did not include testing and treatment. WHO recommends treatment of people diagnosed with HBV[10] and HCV infection.[11] HBV treatment is indicated only for eligible people and it is usually lifelong.[10] Short courses of HCV treatment with direct acting antivirals lead to cure in more than 90% of patients.[11] Treatment can be highly cost-effective or cost-saving from a health-care perspective.[14–16] For testing in all settings, WHO recommends focused testing in people with signs and symptoms of chronic liver disease and groups with high HBV or HCV infection prevalence. However, if the prevalence of infection in the general population exceeds 2–5%, WHO recommends general population testing.[9,17,18]

Progress towards elimination has been modest. Prevention is on track, apart from timely birth dose vaccination in Africa and harm reduction for people who inject drugs.[1,19] However, the coverage of testing and treatment remains low.[20,21] To make the case for scaling up, the argument of affordability needs to complement the argument of cost-effectiveness. Therefore, we aimed to estimate the incremental commodity cost of adding scaled up interventions for testing and treatment of hepatitis to the progress and ambitious scenarios of WHO's SDG investment scenarios.[13]

Methods

Scenarios considered

We extended the methods used for WHO's SDG investment model, in the same 67 countries (appendix p 7) to add testing and treatment for HBV and HCV infection.[13] A first flatline scenario consisted of the continuation of the current testing and treatment approaches until 2030. A second progress scenario consisted of an increase of testing and treatment coverage following the WHO guidelines.[9–11] The third ambitious elimination scenario consisted of a scaling up that would reach the coverage required to achieve HBV and HCV elimination.[2]

General approach

For each of the scenarios, we calculated total commodities cost on the basis of unit price and quantities required. We quantified staffing needs on the basis of interventions required and ensured that these needs fit within the overall requirements that had been already costed.[13] Finally, we added programme support costs to address training, supervision, monitoring, and evaluation. None of the costs were discounted.

Interventions

We focused on testing and treatment because prevention had been included in the SDG investment model. Hepatitis B immunisation, including timely birth dose, is included in the Global Vaccine Action Plan.[22] Modelling studies suggest that this plan should be sufficient to reach a substantial component of the HBV incidence reduction

See Online for appendix

of the hepatitis elimination strategy.[23] The programmatic infrastructure of prevention of mother-to-child transmission of HIV and syphilis would provide additional opportunities to direct treatments to eligible pregnant women, which would further reduce incidence of HBV infection.[24] The overall health system strengthening would improve infection control, including blood and injection safety. Harm reduction for people who inject drugs is included under HIV prevention.[25]

Evolution of the HBV and HCV epidemic in the population

For each of the 67 countries, we extrapolated population size estimates using the Spectrum tool,[26] taking into account the mortality effect of the UHC scenarios.[13] We started with the 2015 prevalence of HBV and HCV infection, and adjusted future prevalence accounting for new infections per yearly incidence rates, mortality, and cures in the case of HCV infection (appendix p 9). We then moved individuals from the status of infected to tested, diagnosed, and started on treatment to project the quantity of resources needed. The annual recalculation of the prevalence of infection ensured that the resources needed for testing and treatment took into account incidence in the case of HCV infection. We assumed the incidence of HCV to be stable for the flatline (and equal to the estimates for each WHO Region in 2015),[1] or decreasing to reach –50% for the progress scenario or –90% for the ambitious scenario, by 2030, because of the prevention interventions. For HBV, we did not consider that new chronic infections would be added among adults (appendix p 3).

Unit cost for resources needed

We reported all costs in US dollars (2018). We used 2018 prices for commodity costs, whereas programme costs were inflated from US dollars in 2010 using country-specific gross domestic product deflators.[27]

We used the 2018 best available prices for commodities recommended by the testing and treatment guidelines (appendix p 10).[9–11] For treatment, we assumed that all countries would optimise procurement and access medicines according to the prices already reported for high volume generic scenarios ($30 per year for HBV, using tenofovir;[20] $105 per cure for HCV, using the pangenotypic sofosbuvir plus daclatasvir regimen).[21,28]

We quantified the human resources (ie, medical doctors and nurses) in terms of minutes (specific for each country) required for testing and treatment irrespective of any integration with other services (appendix p 10). We multiplied this time by the number of tests and treatments initiated. We then checked that staffing needs fitted in the overall human resources requirements estimated in the SDG analysis.[13]

The method for programme costs followed that of the SDG investment scenario and considered management, training, monitoring, and evaluation. We considered that programme costs started in 2016 with 10% of the full

	Flatline scenario				Progress scenario				Ambitious scenario			
	HBV	HCV	Support	Total	HBV	HCV	Support	Total	HBV	HCV	Support	Total
African Region	55 861 392	103 828 534	0	159 689 927	3 246 578 908	860 554 146	3 590 677 603	7 697 810 657	5 104 778 223	3 088 485 190	8 079 024 607	16 272 288 020
Region of the Americas	90 536 098	187 423 471	0	277 959 569	286 820 097	294 095 307	599 895 459	1 180 810 863	1 072 335 584	1 001 054 329	1 349 764 784	3 423 154 696
Eastern Mediterranean Region	79 107 128	602 583 352	0	681 690 480	1 238 499 409	2 079 517 901	1 471 925 920	4 789 943 230	2 316 134 094	3 346 527 311	3 311 833 321	8 974 494 726
Europe	136 590 542	144 900 057	0	281 490 599	587 326 953	496 558 192	499 059 489	1 582 944 634	846 441 027	904 650 955	1 122 883 850	2 873 975 831
South-East Asia Region	230 138 289	207 266 891	0	437 405 180	2 679 332 696	1 042 299 321	1 093 157 847	4 814 789 864	6 358 053 371	4 029 152 695	2 459 605 156	12 846 811 222
Western Pacific Region	4 869 989 541	423 349 351	0	5 293 338 891	11 843 212 207	1 155 441 788	1 868 835 686	14 867 489 681	14 594 732 452	3 649 474 017	4 204 880 294	22 449 086 763
Total	5 462 222 988	1 669 351 657	0	7 131 574 645	19 881 770 270	5 928 466 655	9 123 552 005	34 933 788 930	30 292 474 750	16 019 344 497	20 527 992 011	66 839 811 258
Incremental*	772 825 856	1 512 091 727	0	739 265 871	15 192 008 370	2 746 231 578	9 123 552 005	27 061 791 953	25 592 427 663	12 588 345 371	20 527 992 011	58 708 765 045

HBV=hepatitis B virus. HCV=hepatitis C virus. *Sum of incremental costs each year over the 2016 baseline.

Table 1: **Cost of the flatline, progress, and ambitious scenarios of testing and treatment for HBV and HCV infection in 67 low-income and middle-income countries (2016–30)**

cost, and scaled up these amounts to 50% in 2030 for the progress scenario, and to 100% in 2030 for the ambitious scenario.

As for the broader SDG analysis, we calculated the incremental cost of each of the three scenarios using the 2016 baseline cost as a reference.

Health effect

For the three scenarios, we modelled the health effect secondary to treatments initiated in 2016 on the basis of natural history and effectiveness of treatment.[10,11] We used worldwide extensions of models for HBV[29] and HCV,[30] using background mortality estimated by the UN (appendix p 3). We expressed health benefit in terms of healthy life-years gained and deaths averted before and after 2030 for individuals with treatment initiated between 2016 and 2030 (ie, while individuals are alive). None of the health benefits were discounted.

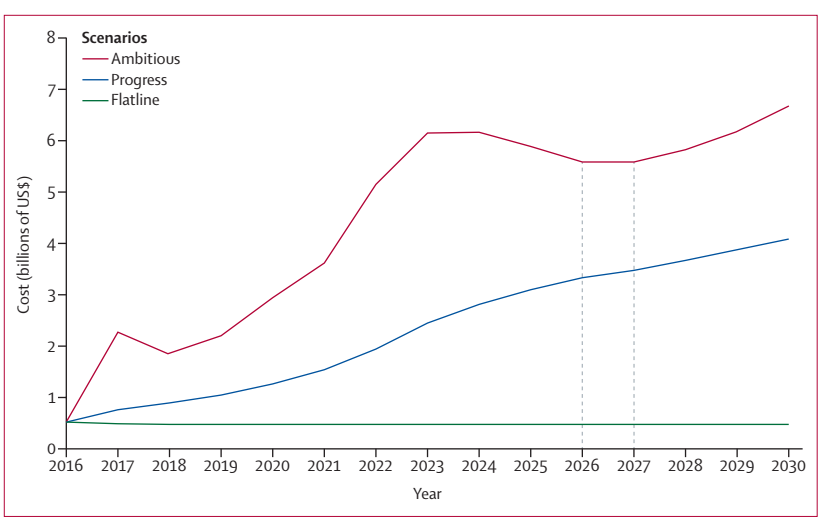

Figure 1: **Annual cost of testing and treatment for hepatitis B virus and hepatitis C virus, by scenario, in 67 low-income and middle-income countries (2016–30)**

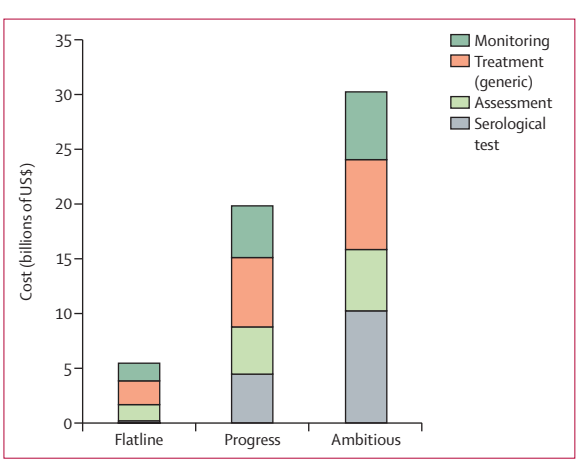

Figure 2: **Costs according to the stage of care for hepatitis B virus testing and treatment, by scenario, in 67 low-income and middle-income countries (2016–30)**

Sensitivity analysis

We did three one-way sensitivity analyses for specific commodity costs. First, we assumed that the incidence of HCV infection did not decline as a result of prevention interventions. Second, we assumed that countries where direct acting antivirals for HCV were still protected by a patent in 2018 had to pay $5000 for a curative short-course treatment. Finally, we assumed that all countries would not have yet benefited from the price reduction of HCV RNA and HBV DNA amplification diagnostics and would pay $115 and $130 for each test, respectively.

Role of the funding source

The funders of the study had no role in study design, data collection, data analysis, data interpretation, or writing of the report. The first and corresponding authors had full access to all the data and had final responsibility for the decision to submit for publication.

Results

The 67 countries considered (2015 total population: 5·6 billion people; appendix p 12) accounted for 230 million people with HBV (90% of HBV infections worldwide; appendix p 12) and 52 million people with HCV infection in 2015 (73% of HCV infections worldwide; appendix p 12).

The cumulative numbers of people tested for HBV infection were 93 million people for the flatline scenario, 2400 million people for the progress scenario, and 5502 million people for the ambitious scenario (appendix p 17). The number of people receiving HBV treatment in 2030 increased from 1·4 million (flatline scenario) to 24·1 million people in the progress scenario and 32·2 million people in the ambitious scenario (appendix p 19).

The cumulative numbers of people tested for HCV infection were 142 million people for the flatline scenario, 850 million people for the progress scenario, and 6129 million for the ambitious scenario (appendix p 18). The cumulative number of people placed on curative HCV treatment in 2030 increased from 10·5 million (flatline scenario) to 34·1 million (progress scenario) and 61·6 million (ambitious scenario; appendix p 20).

The flatline scenario led to a total cost of $7·1 billion, with $5·5 billion (77%) used for HBV and $1·7 billion (23%) used for HCV (table 1). The progress scenario led to a total cost of $34·9 billion. Of this amount, $19·9 billion (57%) was for HBV, $5·9 billion (17%) for HCV, and $9·1 billion (26%) was for programme costs. The additional investment of the progress scenario over a continuation of the 2016 costs was $27·1 billion, accounting for 0·9% of the estimated cost presented by WHO for the SDG progress scenario. The ambitious scenario led to a total cost of $66·8 billion; $30·3 billion (45%) was for HBV, $16·0 billion (24%) was for HCV, and $20·5 billion (31%) was for programme costs. Adding hepatitis activities to the overall WHO SDG ambitious

scenario would require an additional $58·7 billion, accounting for a 1·5% increase in resource needs (table 1).

The requirements in terms of health-care worker time would be 7·5 million days for doctors and 9·4 million days for nurses (flatline scenario); 175·9 million days for doctors and 42·7 million days for nurses (progress scenario); and 432·3 million days for doctors and 247·8 million days for nurses (ambitious scenario).[13]

The cost of the flatline scenario slightly decreased over time, from $524·8 million to $474·5 million (figure 1). The annual cost of the progress scenario consistently increased from 2016 ($524·7 million) to 2030 ($4·1 billion). The annual cost of the ambitious scenario increased until 2023 ($6·2 billion), decreased from 2024 to 2027 ($5·6 billion), and then increased again until 2030 ($6·7 billion). The WHO Regions where the largest investment was needed was the western Pacific (table 1; appendix p 21), followed by Africa, South-East Asia, Eastern Mediterranean, Americas, and Europe.

For HBV, most costs were associated with initial diagnosis (serological test), treatment eligibility assessment, and monitoring (figure 2). Diagnostics (HBsAg and HBV DNA tests) accounted for the majority of the costs (up to 69% in the ambitious scenario; appendix p 22). Medicines accounted only for a minority of the costs (up to 31% in the ambitious scenario). For HCV, the costs were spread between diagnosis, treatment assessment, treatment, and monitoring (figure 3). Diagnostics (anti-HCV and HCV RNA) accounted for 58% and medicines for 42% of the costs in the ambitious scenario (appendix p 23).

Under the hypothesis that the incidence of HCV infection would not be reduced in the progress and ambitious scenarios, the cost of the ambitious scenario for HCV would increase from $16·0 billion to $17·4 billion (appendix p 14). The overall incremental cost of elimination would then reach $60·0 billion (appendix p 14).

In 2017, patents restricted access to generic direct acting antivirals for HCV in 13 countries. Under the hypothesis that they would have to continue to pay $5000 for a direct acting antiviral course, the cost of the ambitious scenario for HCV would increase from $16·0 billion to $106·7 billion. The overall incremental cost of elimination would then reach $118·0 billion (appendix p 14).

In 2018, some countries still paid higher prices for HBV DNA testing ($130 instead of $20 reported in 2018 with optimised procurement mechanisms).[1] Under the hypothesis that such prices would be maintained for all countries, the total cost of the ambitious scenario for HBV would increase from $30·3 billion to $87·7 billion (appendix p 14).

Similarly, in 2018, some countries still paid high prices for HCV RNA testing ($115 instead of $20 reported in 2018 with optimised procurement mechanisms).[1] Assuming that these prices would be maintained for all countries, the total cost of the ambitious scenario for HCV would increase from $16·0 billion to $24·3 billion (appendix p 14).

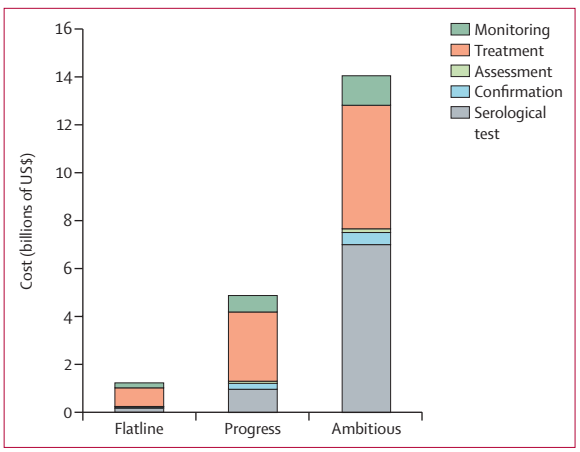

Figure 3: **Costs according to the stage of care for hepatitis C virus testing and treatment, by scenario, in 67 low-income and middle-income countries (2016–30)**

Implementation of the flatline scenario would have limited effect in terms of preventing mortality from HBV or HCV infection (table 2). In contrast, the progress scenario would avert 16·6 million premature deaths, 3·0 million (18%) of which would be before 2030 (table 2). Of the deaths averted, 7·3 million (44%) were associated with HBV infection and 9·3 million (56%) were associated with HCV infection.

Treatment according to the progress scenario would also lead to a gain of 328·6 million healthy life-years, 31·0 million (9%) of which would be before 2030 (table 2). Further, the ambitious scenario would avert 26·8 million premature deaths, 4·5 million (17%) of which would be before 2030. Of the deaths averted in this scenario, 9·7 million (36%) were associated with HBV infection and 17·1 million (64%) were associated with HCV infection.

Treatment according to the ambitious scenario would lead to a gain of 553·7 million healthy life-years, 51·5 million (9%) of which would be before 2030 (table 2). Adding hepatitis elimination to the ambitious SDG scenario would avert additionally more than 97 million (4·6%) premature deaths[13] and add more than 535·8 million (9·6%) healthy life-years[13] from 2016 to 2030.

Discussion

The estimated resource needs for testing and treatment for hepatitis from 2016 to 2030 (over the continuation of the 2016 baseline costs) ranged from $27 billion for the progress scenario to $58·7 billion for the ambitious elimination scenario. Under the ambitious elimination scenario, testing and treatment for HBV and HCV would account for a 1·5% increase in the previously published $3944 billion WHO SDG price tag. Cost estimates and the proportion of the price tag that they account for are

	Deaths averted			Healthy life-years gained			Decompensated cirrhosis cases prevented			Hepatocellular carcinoma cases prevented		
	Flatline	Progress	Ambitious	Flatline	Progress	Ambitious	Flatline	Progress	Ambitious	Flatline	Progress	Ambitious
HBV until 2030	198 289	2 380 607	3 361 518	1 551 122	16 470 601	23 924 254	93 327	1 271 834	1 750 731	109 219	1 442 776	2 006 580
HCV until 2030	286 433	608 713	1 147 167	6 698 067	14 509 316	27 550 471	152 783	307 875	604 880	353 129	804 178	1 525 136
Total until 2030	484 722	2 989 320	4 508 685	8 249 189	30 979 917	51 474 725	246 110	1 579 709	2 355 611	462 348	2 246 954	3 531 716
HBV after 2030	238 139	4 935 635	6 351 287	5 041 431	91 757 313	119 538 846	52 963	1 219 728	1 561 421	82 495	1 901 776	2 451 109
HCV after 2030	2 598 795	8 646 370	15 953 283	59 472 986	205 831 791	382 707 315	1 223 634	3 899 133	7 366 311	2 065 075	6 984 758	12 995 424
Total after 2030	2 836 934	13 582 005	22 304 570	64 514 418	297 589 104	502 246 161	1 276 597	5 118 861	8 927 732	2 147 570	8 886 534	15 446 533
HBV total	436 428	7 316 241	9 712 804	6 592 553	108 227 914	143 463 100	146 289	2 491 562	3 312 152	191 714	3 344 551	4 457 690
HCV total	2 885 228	9 255 083	17 100 450	66 171 054	220 341 107	410 257 786	1 376 417	4 207 008	7 971 191	2 418 204	7 788 936	14 520 560
Total	3 321 656	16 571 324	26 813 254	72 763 606	328 569 020	553 720 886	1 522 706	6 698 570	11 283 343	2 609 918	11 133 487	18 978 250

Table 2: **Summary of the health effect of the flatline, progress, and ambitious scenarios of testing and treatment for hepatitis B virus (HBV) and hepatitis C virus (HCV) infection in 67 low-income and middle-income countries (2016–30 and longer than 2030 for treatments initiated between 2016–30)**

also available for other major infectious diseases, including HIV ($102 billion [2·5%]), tuberculosis ($7 billion [1·4%]), and malaria ($51 billion [1·3%]), and are lower than for non-communicable diseases ($421 billion [10·7%]). For this 1·5% increase in investment over the ambitious SDG scenario, by 2030, hepatitis elimination would avert an additional 4·6% premature deaths and lead to the gain of an additional 9·6% healthy life-years. This scenario assumes that the health system will be successively strengthened to provide the infrastructure and the human resources required for the delivery of these services, including prevention. The 2018 WHO investment case estimated that such an investment in health would have positive returns.[31] Programme costs accounted for $20·5 billion, 31% of the cost under the ambitious scenario. In some settings, some of these costs could be overestimated. According to the various situations, part of the costs could be reduced through efficiency savings from programme synergies or integrated approaches with compatible programmes or services, including HIV, tuberculosis, harm reduction, and correctional health.[11]

Although the price tag of an ambitious scenario for hepatitis testing and treatment represents around 1% relative increase over the overall estimated cost for SDG health investments, affordability will be an issue in low-income countries. For hepatitis, financing solutions will be needed in low-income and middle-income countries where current financing schemes might not capture hepatitis testing and treatment.[32] The Western Pacific and South-East Asia Regions are mostly constituted of middle-income countries where revenue generation through economic growth could finance hepatitis within UHC. Furthermore, increasing health-care costs in these countries means that the cost of inaction in terms of chronic care for cirrhosis and hepatocellular carcinoma could be higher than the cost of paying for testing and treatment. Testing and treatment for HBV[14] or HCV[15] infection is indeed cost saving from a health-care perspective in many countries. In contrast, in the Africa Region, with few exceptions,[33,34] the perspectives for domestic revenue generation for viral hepatitis elimination are less favourable. The limited use of health care for patients with cirrhosis and hepatocellular carcinoma nowadays means that HBV or HCV treatment is less likely to be cost saving from a health-care perspective. Thus, initial external funding through donor support could be crucial in getting testing and treatment initiatives scaled up beyond a small number of initiatives,[35] particularly for HBV, which affects the Africa Region heavily.[1] Finally, in a scenario of increased access to generic prices, middle-income countries of the European and American Regions would require smaller disbursements than other regions. Given the health-care cost for the management of sequelae, testing and treatment would probably be cost saving. However, this scenario requires additional price reductions of curative treatments for HCV in countries where direct acting antivirals are protected by patents.[21]

Scaling up HBV and HCV treatment is highly dependent on the availability and affordability of diagnostics and medicines. A large part of the costs is attributable to the testing because it would require testing a large number of people to identify 90% of those infected in settings of low prevalence. Our costing estimates were sensitive to the price of direct acting antivirals for HCV and HBV DNA tests. Sharp price reductions have taken place.[21] In 2017, 62% of people infected with HCV lived in countries where they should be able to access a curative course of direct acting antiviral for $105. Newer direct acting antiviral regimens could be shorter, allowing for further price reduction.[21] However, in upper middle-income countries, where patents still protect direct acting antivirals, prices reported are around $3000–5000 for a course.[21] Of the countries we considered, 13·1 million people living with HCV (25% of the total population with HCV in the 67 countries) were in countries without access to generics. If these countries were to procure direct acting antivirals at $5000 per course, the ambitious price tag would be higher. For diagnostics, price reduction

strategies (eg, open tenders, bulk procurement) would also have a large effect on feasibility.

Our cost estimates have several limitations. First, estimates are based on specific scenarios created to assimilate WHO recommendations algorithms, selected epidemiological parameters, and assumptions regarding the cost implications (quantities of resources needed and unit cost) in several countries. These estimates did not result from a full dynamic model simulating the joint effect of various interventions for prevention and treatment or to compare the effectiveness of various intervention scenarios with multidimensional sensitivity analyses. Second, our scenarios assume a strengthening of health systems and scaled up delivery of interventions that would prevent HBV and HCV infections but did not model prevention. The ambitious 2015–30 costing to end the AIDS epidemic was based on the UNAID's fast track scenario and included a service package for people who inject drugs (90% coverage) and opioid substitution therapy (40% coverage) designed to reduce needle (by 51%) and syringe sharing (by 71%),[25,13] noting that the target for needle and syringe distribution is higher for HCV than for HIV (300 *vs* 200 per user per year). If that package was not effective at reducing the incidence of HCV infection as we assumed,[36] it would be unfortunate from a public health point of view but would not substantially affect the 2016–30 cost projections. Results of another sensitivity analysis that we did suggests that if incidence of HCV infection was not reduced, the cost of the ambitious scenario would increase from $66·8 billion to $68·2 billion. Third, scenarios are based on assumptions about the efficiency of testing, the probability of being tested twice, and the outcome of testing activities in terms of the proportion of people diagnosed with HBV and HCV infection. These assumptions are mostly theoretical at this stage given the limited real-world experience of programmes to test people from the general population.[37–39] Our projections led to a large number of people who needed to be tested for a 2015 baseline population of 5·6 billion. For HBV, our projections for elimination call for testing 5·5 billion people (0·98 tests per 2015 population). As a reference, a global HBV model called for testing every person once in populations in low prevalence areas.[3] For HCV, our projections for elimination call for testing 6·1 billion people (1·1 tests per 2015 population). As a reference, a similar type of analysis done in Malaysia called for testing a total of 6 million people for an adult population of 18 million to reach elimination.[40] A global investment case estimated that reaching HCV elimination would require testing 70% of the global adult population.[35] More experiences are needed so that we can better quantify the outcome of such programmes. Fourth, our analysis did not take into account the savings to the health sector because of prevented decompensated cirrhosis and hepatocellular carcinoma. These savings were estimated in the cost-effectiveness analyses that are complementary to our cost projections.[41,42] In high-burden settings, elimination would lead to a positive return on investment.[43,44] Finally, our cost projections are based on the assumption that 25% of people with HBV infection would be eligible for treatment. WHO-endorsed global estimates of the proportion of HBsAg-positive people who are eligible for treatment are not available. Published studies in selected countries suggest that the proportion of eligibility ranges from under 5% in community-based studies in Africa[37] to around 25% in health-care facility-based studies.[45,46] A higher or lower proportion of people eligible for treatment would decrease or increase the effect of testing and treatment programmes, respectively.

In conclusion, the estimation of the price tag for testing and treatment of HBV and HCV infection points to three main conclusions. First, additional resources needed for testing and treatment of HBV and HCV infection within a broader UHC ambitious scenario represents an additional 0·9% and 1·5% of UHC price tag for the progress and ambitious scenarios, respectively. Second, the Western Pacific and African Regions need to invest the most, given population sizes and prevalence of HBV infection. Third, the price of HBV DNA tests and HCV direct acting antivirals are the main cost drivers. These conclusions point to several recommendations. First, WHO member states should consider that hepatitis testing and treatment is a high-impact intervention that deserves to be funded as part of UHC. Integrated service delivery models[11] would improve programme efficiency. Second, WHO member states should consider optimising procurement of affordable medicines effective against HBV and HCV infection along with WHO flowcharts.[21] For tenofovir and for countries where direct acting antivirals are not protected by a patent, countries need to register products from multiple generic manufacturers to encourage competition with tenders. In countries where direct acting antivirals are protected by a patent, national programmes need to negotiate price and volume with originators until the price reached is compatible with national scaled up implementation.[21] Third, appropriate forecasting, open tenders, and bulk procurement for price–volume reductions should take place so that the price of diagnostics tests can decrease. If the price of nucleic acid tests, such as HBV DNA and HCV RNA, were to decrease to less than $5 per test—a price mentioned as a possible target in the field of diagnostics[47]—elimination could be greatly facilitated. Implementation science could also identify better service delivery models and alternative, more cost-effective ways to monitor the effectiveness of treatment in people treated for HBV infection through, for example, the use of liver function tests instead of HBV DNA. Implementation of these recommendations provide a feasible way forward to reach elimination of hepatitis in the context of UHC.

Contributors

DT developed the cost projection model and the economic analysis according to a concept from KS and with the assistance of JAL. DWH and MT designed the model for HBV disease progression. NS designed the model for HCV disease progression. YH coordinated the project and wrote the first draft of the manuscript with the assistance and leadership of MB, AB, and GH. All authors contributed to editing and revising the manuscript, and approved its final version.

Declaration of interests

We declare no competing interests.

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