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ORIGINAL ARTICLE

HCV disease burden and population segments in Switzerland

Florian Bihl[1,2] | Philip Bruggmann[3] | Erika Castro Batänjer[4] | Jean-Francois Dufour[5] | Daniel Lavanchy[6] | Beat Müllhaupt[7] | Francesco Negro[8] | Homie Razavi[9] | Claude Scheidegger[10] | David Semela[11] | Nasser Semmo[12] | Sarah Blach[9]

[1]Gastroenterology and Hepatology Department, Ente Ospedaliero Cantonale, Bellinzona, Switzerland

[2]Divisions of Gastroenterology and Hepatology, University Hospital, Geneva, Switzerland

[3]Arud Centre for Addiction Medicine, Zurich, Switzerland

[4]Hepatitis C Virtual Clinic and Private Practice, Lausanne, Switzerland

[5]University Clinic for Visceral Surgery and Medicine, Inselspital, University of Bern, Bern, Switzerland

[6]Consultant, Denges VD, Switzerland

[7]Swiss HPB (Hepato-Pancreato-Biliary) Center and Department of Gastroenterology and Hepatology, University Hospital Zürich, Zürich, Switzerland

[8]Divisions of Gastroenterology and Hepatology and of Clinical Pathology, University Hospital, Genève, Switzerland

[9]CDA Foundation, Lafayette, Colorado, USA

[10]Private Practice, Basel, Switzerland

[11]Division of Gastroenterology & Hepatology, Cantonal Hospital, St. Gallen, Switzerland

[12]Department for BioMedical Research, Hepatology, University of Bern, Bern, Switzerland

Correspondence
Florian Bihl, Gastroenterology and Hepatology Department, Ente Ospedaliero Cantonale, Bellinzona, Switzerland.
Email: Florian.Bihl@eoc.ch

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Abstract

Background: Switzerland has made strides towards hepatitis C virus elimination, but as of 2019, elimination was not guaranteed. However, political interest in viral hepatitis has been increasing. We sought to develop a better understanding of Switzerland's progress towards HCV elimination and the profile of remaining HCV-RNA-positive patients.

Methods: A previously described Markov model was updated with recent diagnosis and treatment data and run to generate new forecasts for HCV disease burden. Two scenarios were developed to evaluate HCV morbidity and mortality under the status quo and a scenario that achieves the Swiss Hepatitis Strategy Elimination targets. Next, an analysis was conducted to identify population segments bearing a high burden of disease, where future elimination efforts could be directed.

Results: At the beginning of 2020, an estimated 32 100 viremic infections remained in Switzerland (0.37% viremic prevalence). Adult (≥18 years of age) permanent residents born abroad represented the largest subpopulation, accounting for 56% of HCV infections. Thirteen countries accounted for ≥60% of viremic infections amongst permanent residents born abroad, with most people currently residing in Zurich, Vaud, Geneva, Bern, Aargau and Ticino. Amongst Swiss-born HCV-RNA-positive persons, two-thirds had a history of IDU, corresponding to 33% of total infections.

Conclusions: In Switzerland, extra efforts for diagnosis and linkage to care are warranted in foreign-born populations and people with a history of drug use. Population-level measures (eg increasing the number of providers, increase screening) can identify patients who may have otherwise fallen through the gaps or avoided care because of stigma.

KEYWORDS
elimination, hepatitis C Virus, migration, Switzerland

1 | BACKGROUND

Switzerland has always been a leader in harm reduction which has been successful in keeping the number of new hepatitis C virus (HCV) infections in the country low. However, compared with previous forecasts for HCV elimination in Switzerland, the annual number of patients diagnosed with HCV has not kept pace with prior forecasts (Figure 1).[1,2] Similarly, the number of patients initiated on treatment each year has declined below previous forecasts, except in 2018 when the removal of treatment restrictions resulted in a 1-year expansion in treatments that exceeded prior expectations.[1,3] Treatment further declined in 2020 during the COVID-19 pandemic, but this decline is expected to be temporary. Assuming diagnosis and treatment return to and continue at 2019 levels, Switzerland will no longer be considered "on-track" for elimination, as defined by either the World Health Organization (WHO) or the Swiss Hepatitis Strategy (SHS).

In spite of declining diagnosis and treatment, political interest in hepatitis programming has begun to increase. In 2020, the Swiss Parliament decided to include viral hepatitis in the upcoming new version of the national HIV/STI programme.[4] Additionally, the Federal Commission on Sexually Transmitted Infections (EKSI) wrote a 'Roadmap for eliminating HIV/AIDS and Hepatitis in Switzerland' for the attention of the Federal Council, which will guide the new national programme. In light of this interest, we sought to develop a better understanding of Switzerland's progress towards HCV elimination and the profile of HCV-infected patients remaining in the country. Additionally, this analysis seeks to define and provide support for strategies and interventions to continue moving patients through the cascade of care.

Key points

- In Switzerland, political interest in HCV elimination has been increasing, although HCV elimination is not yet a guarantee.
- To support elimination efforts, we sought to better understand the populations still infected with HCV in the country.
- People with a migration background account for the majority of HCV infections remaining in the country.
- Future strategies to diagnose and treat patients in the country should focus on this population.

2 | METHODS

A previously described Markov state model populated with data for Switzerland[1,5,6] was updated with recent diagnosis and treatment data and run to generate new forecasts for HCV disease burden. Two scenarios were developed to evaluate the HCV-related morbidity and mortality under the status quo and under a scenario that achieves the SHS Elimination targets.

After modelling the disease burden of HCV in the general population in Switzerland, an analysis was conducted to identify population segments bearing a high burden of disease where future elimination efforts could be directed. Populations of interest were defined in a series of expert panel discussions to ensure that vulnerable and high-burden groups were considered. For this final analysis, the following populations were included: incarcerated people, people who use drugs (PWUD) (currently) and opioid agonist therapy (OAT) participants, adult (18+) permanent residents by country of birth, people with high-risk sexual behaviours (including HIV + men who have sex with men (MSM) and people engaging in chemsex).

2.1 | HCV disease burden model

HCV prevalence, prevalence by age and sex, and the number of persons previously diagnosed and treated were used to seed and calibrate the model. Many of these inputs have been described in detail previously,[1,5,6] with newer inputs described briefly here. The annual number of cases notified to the Swiss Federal Office of Public Health (FOPH) was used to estimate the number of persons newly diagnosed, assuming a viremic rate of 79%.[2,7] The number of patients previously diagnosed with HCV was calculated following a previously published process[1] but considering recently released data (including estimates for mortality, cure and newly diagnosed). The number of

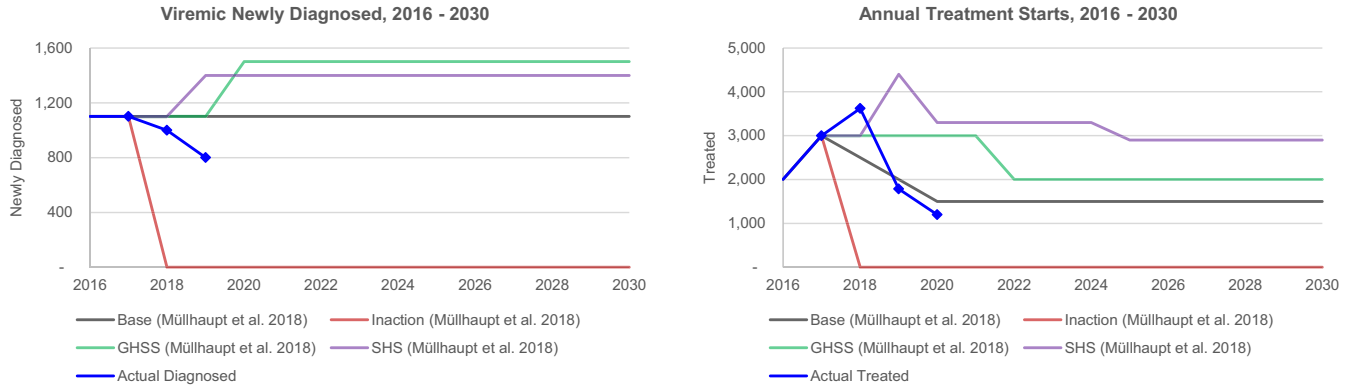

FIGURE 1 Comparison of empirical diagnosis and treatment data from 2016 to 2020 against previously forecast scenarios published in Müllhaupt et al (2018). GHSS, global health sector strategy; SHS, Swiss hepatitis strategy

patients initiated on DAA treatment annually was accessed through a variety of sources including the Swiss Pharmacist Cooperative (OFAC), the Swiss National Pharmacy Service (Mediservice) and industry data sources.

The number of new infections through 2015 was calculated in previous studies[1,8] and was maintained in this analysis model within the same year. After 2015, the impact of HCV treatment as prevention was calculated in the model for horizontally and vertically acquired incident infections. Horizontally acquired infections were calculated as a function of prevalence in future years, considering fibrosis restrictions for treatment. In years with reimbursement restrictions (ie F1 or greater on the METAVIR scale), future horizontal incident cases were assumed to change at the same rate as modelled F0 prevalence. Once restrictions were removed (ie F0 on the METAVIR scale), future horizontal incident cases were assumed to change at the same rate as total prevalence.

2.2 | Uncertainty analysis

Crystal Ball release 11.1.2.3.500 was used to calculate uncertainty intervals (UIs) and conduct sensitivity analyses. β-PERT distributions were used for all uncertain inputs. A Monte Carlo simulation with 1000 trials was used to estimate 95% UIs.

2.3 | Modelled scenarios for the elimination of HCV in Switzerland

Once the model was developed, two "what-if" scenarios were run to evaluate the impact of future decisions, as follows:

A baseline scenario (Base 2019) was developed using empirical diagnosis and treatment data through 2019. Additionally, the preliminary impact of COVID-19 on HCV diagnosis and treatment was considered, using monthly sales forecast and notification data through the first half of 2020, with extrapolations for the remainder of the year. Although the full extent of COVID-19-related delays is yet to be seen, for this exercise, treatment and diagnosis were expected to rebound in 2021 to the levels previously seen in 2019. After 2021, assuming no major improvements in case finding or linkage to treatment, the number of patients starting treatment each year was modelled to remain roughly constant.

Additionally, a scenario was developed to identify the steps needed to achieve the SHS elimination targets of a 90% reduction in HCV-related morbidity and mortality by 2030.

2.4 | HCV prevalence amongst subpopulations

To evaluate the distribution of HCV infections by subpopulations, the population size and HCV prevalence were identified through government reports, peer-reviewed literature, and unpublished data. Two meetings were held to review all outcomes and to identify data gaps. When possible, overlap amongst subgroups was considered and quantified. Finally, the number of HCV + persons within each subgroup as well as the proportion of total infections that each subgroup accounted for was calculated as follows: the number of viremic infections by subgroup/the number of viremic infections in Switzerland. The methodology for estimating subpopulation size and prevalence is discussed briefly here with more details available in the Appendix.

2.4.1 | Pediatric and adolescent

In Switzerland, children and adolescents (under 18 years of age) are at very low risk of acquiring HCV. A recent study found that the prevalence of HCV amongst children and adolescents in Switzerland was 0.03%-0.05%.[9]

2.4.2 | Adult permanent residents by migration status (born abroad/Swiss-born)

The numbers of adult (at least 18 years of age) Swiss permanent residents born abroad (obtained from the Swiss Federal Statistics

Office)[10] and adult HCV-RNA prevalence by countries of origin (unpublished data obtained from the Polaris Observatory) were used to calculate the number of HCV infections amongst persons born abroad (Appendix Section 1). A recent analysis of foreign-born persons in the Swiss Hepatitis C Cohort was incorporated to segment the HCV + population born abroad by history/no history of IDU.[11] HCV + asylum seekers and undocumented immigrants could not be quantified as part of this analysis because of a lack of available data.

The number of adult Swiss-born permanent residents with HCV was calculated by subtracting the number of HCV infections amongst persons born abroad from the total number of HCV infections in Switzerland. This population was further segmented according to a history of IDU, based on data from the Swiss Hepatitis C Cohort.[11]

2.4.3 | People who use drugs (PWUD)

The number of PWUD (defined here as people who inject drugs [PWID] and people who do not inject drugs but are engaged in OAT) was collected from a recent modelling study.[8] The modelling study also found a viremic prevalence of 42% amongst PWUD in 2015; however, since that time, efforts to eliminate HCV amongst PWUD have increased. To better estimate the number of viremic infections amongst PWUD, unpublished data and expert consensus was used to segment the PWUD population by provider type (specialist or general practitioner [GP]), assuming that most PWUD who are engaged in specialist care have received treatment for HCV (Appendix Section 2).

2.4.4 | Incarcerated

The number of incarcerated persons was available from the Swiss Federal Statistics Office.[12] This estimate was then segmented on the basis of PWID and non-PWID, with HCV prevalence estimates obtained from a cross-sectional study of the Champ-Dollon prison (Appendix Section 3).[13]

2.4.5 | People with high-risk sexual behaviours

A 2011 estimate from UNAIDS suggests that there were around 20 000 female sex workers (FSW) in Switzerland[14] and a recent publication suggests an HCV-RNA prevalence of 0.2% (95% CI: 0.0%-1.3%) among FSW in 2016/2017.[15] However, more than 95% of FSW tested for HCV lived in the German-speaking part of Switzerland, and only two HCV-RNA-positive cases were identified.[15] Additionally, the overall population size after 2011, and overlap with other risk groups (including PWUD and OAT participants) are unknown.

There were an estimated 80 000 MSM in Switzerland,[16] but the number engaged in high-risk sexual behaviours was harder to estimate. As a result, HIV status was used to segment the population to calculate HCV prevalence, with an estimated 8.0% of the MSM population living with HIV in 2012.[16] In the Swiss HIV cohort, the prevalence of HCV was close to 4.8% in 2015-2016, but this has since reduced through concerted treatment efforts.[17] By 2017, the prevalence of HCV in HIV + MSM was 0.8% in the cohort.[17]

The number of HIV + MSM who use chemsex drugs, as well as the prevalence of HCV was available from a recent analysis of the Swiss HIV cohort.[18] The impact of HCV treatment efforts in the HIV + MSM population on the prevalence amongst HIV + MSM who use chemsex drugs is unknown.

Amongst HIV − MSM, the prevalence of HCV was assumed to be the same as in the general population (Expert Consensus). Trends of new HCV infections amongst HIV − MSM could not be identified.

Within the Swiss Association for the Medical Management in Substance Users (SAMMSU) cohort; the HCV-RNA prevalence was 13.8%, with a higher HCV prevalence and lower HCV-treatment uptake seen HIV-positive patients (26.7%).[19]

2.5 | Migration status by country of origin and canton of residence

Approximately 38% of the Swiss adult permanent resident population has a migration background, making foreign-born residents an important population for further analysis. In addition to the subpopulation analysis for adult Swiss permanent residents born abroad (as described above), the countries representing 60% of HCV infections amongst permanent residents born abroad were included in an in-depth analysis, stratifying by country of origin and canton of residence (Appendix Section 1). The goal was to determine how and where to best target screening and treatment efforts for these populations. Results were described geographically through the generation of heat maps using Microsoft Excel 365 and Bing Maps, as well as graphically using the Sankey minimal template developed by Data Embassy in Tableau Desktop version 2020.1.0.

3 | RESULTS

3.1 | Present and future burden of HCV in Switzerland under the base and SHS scenarios

Since the publication of the Swiss situation analysis in 2016, the number of prevalent viremic infections in Switzerland has declined, primarily because of HCV treatment (Figure 2A). At the beginning of 2020, there were an estimated 32 100 (95% UI: 21 700-34 100) viremic infections remaining in Switzerland (0.37% [95% UI: 0.25%-0.39%] viremic prevalence) (Figure 2B). By the end of 2020, an estimated 58% were expected to have been previously diagnosed, with 4% treated annually with high SVR therapies (>95% SVR) (Figure 2B). Annual treatment starts were estimated to drop 30%, from 1780 in 2019 to around 1000 in 2020 owing to the COVID-19 pandemic (Unpublished data provided by Dr Bruggmann).[3] In 2019, there were 1209 case reports notified to the FOPH or approximately 820 newly diagnosed viremic infections.[2] Data from the first 49 weeks of 2020 showed 841 case reports or 670 newly diagnosed

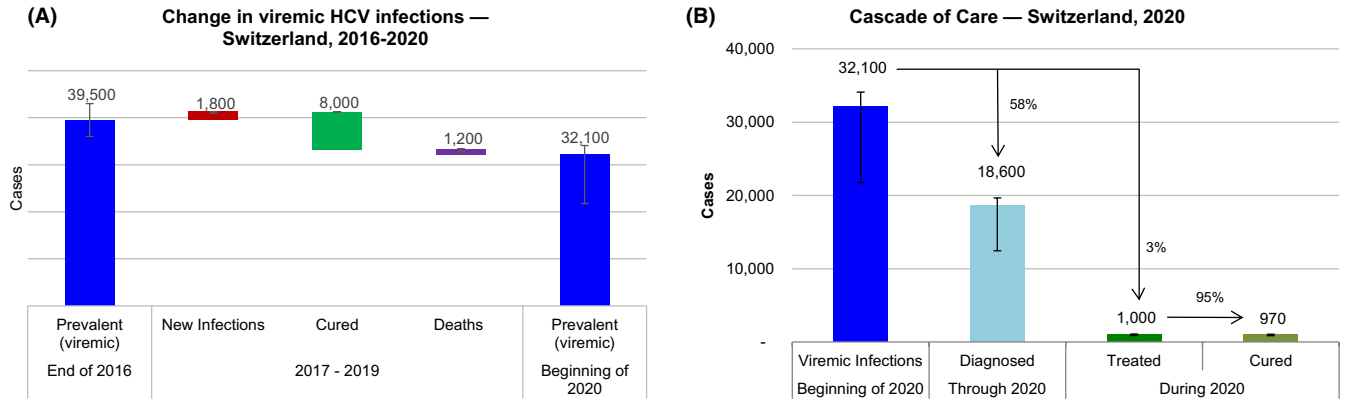

FIGURE 2 A, Change in viremic HCV infections in Switzerland from 2016 to 2020. B, Cascade of care in Switzerland, 2020

viremic infections.[2] Extrapolating for the remaining weeks would correspond to around 710 newly diagnosed viremic infections over the course of 2020, a 15% reduction from 2019.

Assuming the impact of COVID-19 does not extend beyond 1 year, and HCV diagnosis and treatment rebound to 2019 levels by 2021, 17 800 patients would be projected to initiate treatment with 8200 newly diagnosed from 2021 to 2030 (Table 1). Assuming a continued low-level of new infections through local transmission or migration, there would be 18 700 viremic infections remaining in 2030, a 57% reduction compared with 2015. End-stage outcomes, including HCV-attributed liver-related deaths and incident hepatocellular carcinoma (HCC), would also decrease by 58% and 47%, respectively, between 2015 and 2030 (Figure 3).

Achieving the SHS targets of a 90% reduction in HCV-attributed morbidity and mortality (including prevalence, liver-related deaths, etc) would require newly diagnosing 15 200 patients between 2021 and 2030, an increase of more than 7000 diagnosed patients compared with the base scenario in the same time frame. Similarly, 32 200 patients would need to be initiated on treatment over the next 10 years, more than doubling the number of patients estimated to be treated under the base scenario. These scale-ups can occur in a variety of ways, one option is presented in Table 1, where diagnosis and treatment efforts scale up rapidly in 2021 and are slowly reduced over time. The impact of this scenario is shown in Figure 3.

3.2 | Uncertainty analysis

The key drivers of uncertainty for model prevalence in 2020 were the input range around starting prevalence in 2016, and uncertainties around acute HCV to spontaneous clearance rate, and mild to moderate fibrosis transition rates (Appendix Section 4).

3.3 | Proportion of total HCV infections by subpopulation

Adult permanent residents born abroad represent the largest subpopulation with HCV in Switzerland, accounting for 56% of HCV infections in 2019 (Table 2). The majority of foreign-born permanent residents have no history of IDU. By contrast, amongst Swiss-born people with HCV, two-thirds had a history of IDU,[11] corresponding to 33% of total infections in Switzerland (Table 2). However, not all persons with a history of IDU are actively using drugs or are engaged in addiction services.

Not considering migration status, an estimated 18%-29% of viremic infections in Switzerland are among PWUD and OAT participants (Table 2). Within this population, the prevalence of HCV amongst people engaged in specialist care is expected to be lower than people engaged in GP care (Appendix). Other risk groups, including incarcerated persons, and persons with high-risk sexual behaviours (including FSW and MSM) account for no more than 5% of remaining viremic infections (Table 2).

3.4 | HCV prevalence amongst permanent residents born abroad

In total, we estimated there were 17 800 viremic infections amongst Swiss permanent residents born abroad (56% of all viremic infections in Switzerland). In order to successfully direct policies to screen and treat these populations, an analysis of the country of birth was performed. Nationally, 28 countries accounted for ≥80% of adult permanent residents born abroad, with 35 countries accounting for ≥80% of viremic infections amongst adult permanent residents born abroad. Focusing on countries that accounted for ≥60% of viremic infections amongst adult permanent residents born abroad would leave 13 most frequent countries of birth (Bosnia and Herzegovina, France, Germany, Italy, Kosovo, North Macedonia, Portugal, Romania, Russia, Serbia, Sri Lanka, Syria and Ukraine) (Appendix Section 1).

Lastly, viremic infections were analyzed by country of birth and canton of current residence to determine not only which groups should be prioritized for screening and treatment but also where in the country to implement culturally competent awareness campaigns to best reach patients. Considering the 13 countries which, nationally, represent ≥60% of HCV infections amongst adult permanent residents born abroad, most are currently residing in Aargau,

TABLE 1 Annual number diagnosed and initiating treatment as well as treatment eligibility and SVR under the base and SHS scenarios, 2019-2030

Scenario input	Scenario	2019	2020	2021-2022	2023-2024	2025-2026	2027-2028	2029-2030	Cumulative 2021-2030
Newly diagnosed (Viremic)	Base	820	820	820	820	820	820	820	8200
	SHS	820	820	3600	2000	1000	500	500	15 200
Initiating treatment	Base	1780	1200	1780	1780	1780	1780	1780	17 800
	SHS	1780	1200	4200	4000	3200	3000	2700	32 200
Treatment eligibility, fibrosis stage	All scenarios	≥F0	≥F0	≥F0	≥F0	≥F0	≥F0	≥F0	–
Treatment eligibility, age (y)	All scenarios	15-85+	15-85+	15-85+	15-85+	15-85+	15-85+	15-85+	–
SVR	All scenarios	95%	95%	97%	97%	97%	97%	97%	–

Bern, Geneva, Ticino, Vaud and Zurich (Appendix Section 5). Canton-level heat maps depicting the percent of viremic HCV cases amongst permanent residents born abroad, by country of birth (for countries accounting for ≥60% of viremic cases born abroad) and aggregated for former Yugoslavian countries are shown in (Appendix Section 6).

4 | DISCUSSION

The prevalence of HCV is decreasing in Switzerland, primarily owing to increased treatment and prevention efforts. However, the annual numbers of newly diagnosed and treated patients are declining which pose a threat to Switzerland's progress towards HCV elimination by 2030. More than half of prevalent infections in the country are estimated to be diagnosed, but these patients may not currently be under the care, may be under care with a provider who is unaware of the latest guidance for HCV treatment, or may be under care but contraindicated for treatment (eg patients with an estimated life expectancy <12 mo). This raises an important question of how to engage previously diagnosed patients throughout the cascade to ensure successful linkage to care and treatment. One option for addressing this would be to improve awareness of HCV management and treatment amongst general practitioners and other frontline healthcare professionals who may not know about newer therapies.

Our analysis identified that 18%-29% of viremic infections in Switzerland are amongst active PWUD and OAT participants, with <2% amongst incarcerated populations, and up to 3% amongst people with high-risk sexual behaviours (including FSW and MSM). Destigmatizing HCV is an important step toward elimination, which includes lowering the barrier to HCV screening and treatment by expanding to settings where patients already feel comfortable. The prevalence of viremic HCV among PWID engaged in specialist care was estimated to be lower than among PWID engaged with GPs. GPs are currently not allowed to prescribe HCV treatment in Switzerland, however, expanding the base of specialists who can prescribe HCV medications could increase access for this population. One example of this would be providing HCV treatment during a patient's addiction recovery stay in addiction and psychiatric housing structures (EPSM), which has already been successfully tested at a small scale in Canton Vaud.[20] This is supported by a recent modelling study, which found that scaling-up HCV screening to include all psychiatry admissions would be cost-effective, over the current risk-based screening.[21] Targeting sexually transmitted infection (STI) clinics, including sexual health and clinics (PROFA) as partners for awareness and treatment, referral could effectively reach individuals with high-risk sexual behaviours (including chemsex) as it is successfully done, for example in the Checkpoint outpatient clinics for MSM. Alliances with community-based and patient-led-related organizations (drug users, LBGT, sex workers, etc) could significantly improve retention in care for patients facing stigma or other challenges (chaotic lifestyles, challenges making appointments, etc) associated with their risk factors or HCV status.

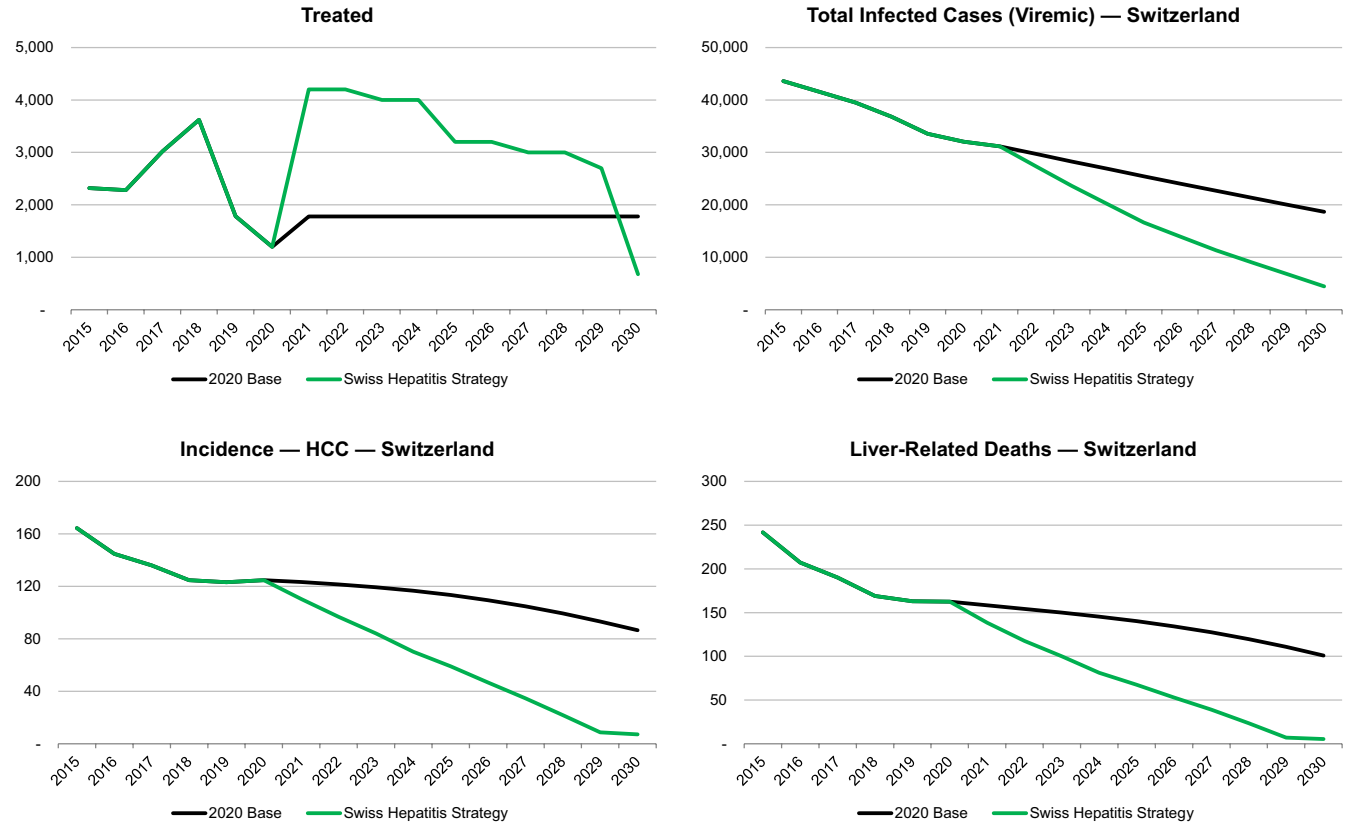

FIGURE 3 Annual number of treated patients and projected outcomes for total viremic infections, liver-related deaths, and incident HCC amongst people with current viremic infection, under the base and SHS scenarios, 2015-2030

Our analysis additionally estimated that around 56% of viremic infections in Switzerland were amongst adult permanent residents born abroad, making this the largest subpopulation with HCV in the country. This is higher than a recent study which found that 32% of persons enrolled in the Swiss Hepatitis C Cohort Study (SCCS) and 23% of viremic infections diagnosed and notified to the FOPH were amongst foreign-born.[11] Two key differences with our study are the focus on total viremic HCV infections (diagnosed and undiagnosed) rather than just diagnosed infections and the exclusion of spontaneously cleared as well as treated and cured patients (ie HCV-RNA-positive only). Even if foreign-born persons accounted for only 23% of all viremic infections, our analysis suggests that they would still represent the second largest subpopulation with HCV in Switzerland, and therefore warrant continued attention for HCV screening and treatment. One way to improve testing and linkage to care in this group could involve engaging immigration centres and pharmacies, which often serve as first points of contact for immigrants. Pharmacists could also provide testing and referrals to OAT patients. Currently, treatment restrictions prevent pharmacists or PROFA clinics from initiating patients on treatment, but these settings could still serve as effective testing and referral centres.

Given the drop in newly diagnosed patients that occurred prior to 2020, increased efforts to screen and identify new patients will be needed for Switzerland to rebound from the COVID-19 pandemic. Enhanced collaboration around HCV awareness and testing within the HIV/STI field is already expected for 2023, via the upcoming new National Program on HIV, Hepatitis and STI. However, Swiss adult permanent residents born abroad, people with a history of injection drug use and people with current drug use or addiction treatment represent the majority of 'known' subpopulations with HCV in Switzerland. Because of considerable overlap amongst these subpopulations, it is difficult to estimate the size of the 'unknown' subpopulations. These could include individuals with prior nosocomial risk factors, healthcare workers or individuals with past risk factors such as unsanitary tattooing. Population-based screening programmes could be initiated alongside testing for other viral illnesses (eg integrating HCV testing into seroprevalence surveys for other diseases with random general population arms, testing of biobank specimens collected during the COVID-19 pandemic) to reach individuals who may not be captured in risk-based screening programmes. Additionally, reimbursement of rapid tests by health insurance and availability of self-testing would have the potential to further lower the threshold in access to testing.

4.1 | Limitations

A few limitations exist within our analysis. First, when modelling the baseline scenario in the context of COVID-19, it is impossible to know the full extent of the delay or disruption while the crisis

TABLE 2 Population size and HCV prevalence amongst subpopulations as well as the calculated proportion of each subgroup relative to total infections in Switzerland (n = 32 060) (categories are not all mutually exclusive), 2020

Population	Population size	HCV-RNA prevalence	HCV-RNA + infections	Calculated proportion of total infections (n = 32 060), 2020[a]
Pediatric	1.5 million	0.03%-0.05%[9]	440-840[9]	1%-3%
Adult (18+ y) permanent residents born abroad				
Total	2.4 million	Varies by country	17 800	56%
No history of IDU	—	—	10 500	33%[11]
History of IDU	—	—	7300	23%[11]
Adult (18+ y) Swiss-born permanent residents				
Total	4.6 million	0.3%[b]	13 650	43%
History of IDU	—	—	9010	28%[11]
No history of IDU	—	—	4640	14%[11]
Active PWUD and OAT participants by care provider				
Total	**23 150**[8]	25%-40%	5790-9260	18%-29%
GP	13 850	42% (20%-44%)[8]	2800-6020	9%-19%
Specialist	9310	<1%-38%	90-3540	0.3%-11%
Incarcerated				
Total	**6905**[12]	**5%-10%**[12]	350-690	1%-2%
PWID	405[12,13]	81.2% (Anti-HCV)[13]	260	0.8%
Non-PWID	6500[12,13]	1.6% (Anti-HCV)[13]	80	0.2%
High risk sexual behaviours				
FSW	**20 000**[14]	0.2% (0.0%-1.3%)[15]	40-260	0.1%-0.8%
Total MSM	80 000[16]	—	410-770	1%-2%
HIV + MSM, chemsex drugs	1630[16,18]	13.6%-25.6% (Anti-HCV)[18]	150-330	0.5%-1.0%
HIV + MSM, no chemsex drugs	4670[16,18]	<0.8%-4.8%[17]	40-220	0.1%-0.7%
HIV-MSM	73 700[16]	0.3%	220	0.7%

[a]Percent of total HCV-RNA-positive infections in Switzerland at the beginning of 2020 calculated as follows: number of infections amongst subgroup/total infections in Switzerland (n = 32 060).

[b]Prevalence was back-calculated as follows: the number of infections/population size; split between GP and specialist care was estimated through unpublished data and expert consensus.

is ongoing, or how the country's HCV elimination progress will rebound after. For this work, we have not only assumed a 1-year decline in diagnosis and treatment but also assumed that efforts will be made to improve screening and treatment after the pandemic subsides. If screening and treatment efforts do not recover, we could expect worse outcomes with regards to HCV-related liver cancers and deaths. Secondly, there is potential for overlapping risk factors within subpopulations that cannot be fully controlled. As a result, these data are useful for directing interventions but are imperfect for determining the prevalence of HCV in the country. Thus, the overall prevalence in Switzerland was modelled forward to the present day using data from the Swiss Situation Analysis, considering DAA treatment, average SVR and mortality (both background and liver-related). Along these same lines, when estimating the size and prevalence of HCV amongst subpopulations in Switzerland, the expert consensus was used for some measures (including more updated estimates of PWUD, and the prevalence of HCV amongst HIV-MSM), where empirical data were outdated, unavailable, or incomplete.

Our analysis of HCV amongst persons born abroad has a few limitations as well. First, this was a cross-sectional analysis of adult permanent residents born abroad who were currently living in Switzerland in 2019, meaning that we could not look at migration dynamics (including age or duration in the country) over time. While permanent residents are more likely to remain in the country for some time, this group may include people who have lived in Switzerland for decades or only a few years. To reflect the changing situation of HCV globally, we used adult viremic prevalence data from 2020 (obtained from the Polaris Observatory). Another limitation was that while the 13 countries studied in depth for the migration analysis represent ≥60% of viremic HCV infections nationally, they did not necessarily represent ≥60% of viremic infections within each canton. In Geneva, for example, the countries studied only represent 47% of HCV infections among foreign residents born abroad.

Expanding the analysis to include country of origin for countries representing ≥60% of infections within each canton (in addition to countries accounting for ≥60% of infections nationally) would be a valuable follow-up analysis for directing policy at the canton level.

5 | CONCLUSIONS

Switzerland has made strides towards HCV elimination, but modelling efforts show that the country is falling short of the 2030 targets. Foreign-born permanent residents and people with an ongoing history of IDU represent the largest subpopulations, suggesting extra efforts for diagnosis and linkage to care are warranted in these groups. In addition, population-level measures such as increasing the number of providers who can test and treat for HCV, can identify patients who may have otherwise fallen through the gaps or avoided care because of real or perceived stigma.

ETHICS APPROVAL STATEMENT

N/A.

PATIENT CONSENT STATEMENT

N/A.

PERMISSION TO REPRODUCE MATERIAL FROM OTHER SOURCES

N/A.

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CONFLICT OF INTEREST

PB has received speaker honoraria and project and research grants from AbbVie and Gilead and project grants from the Swiss Federal Office of Public Health. ECB has received grants from AbbVie and Gilead and has been an expert advisor for ViiV Health Sciences in Switzerland. J-FD has been a member of advisory boards for Abbvie, Bayer, Bristol-Myers Squibb, Falk, Genfit, Genkyotex, Gilead Sciences, HepaRegenix, Intercept, Lilly, Merck, Novartis, Roche. Speaking and teaching: Bayer, Bristol-Myers Squibb, Intercept, Genfit, Gilead Sciences, Novartis and Roche. BM has received speaker and/or consulting fees from Merck/MSD, AbbVie, Intercept, Astra, Bayer, BMS, Gilead and research support from Gilead. FN has received grant support from Gilead and advisor fees and travel grants from Gilead and AbbVie. HR has been a member of advisory boards for Gilead, AbbVie, Merck and VBI Vaccines. All proceeds are donated to CDAF. He is the managing director of Center for Disease Analysis (CDA) and CDAF. CS has been a member of advisory boards for Gilead, AbbVie and Merck. He has received fees for presentations in the context of continuous medical education from various institutions including public and private sources. DS has received research grants, consulting fees and/or speaker fees from AbbVie, Gilead and MSD. NS has been a member of advisory boards for Gilead and AbbVie. SB is an employee of the Center for Disease Analysis Foundation (CDAF). Over the past 3 years, CDAF has received research funding from Gilead, AbbVie, and Vaccine Impact Modeling Consortium. CDAF has also received grants from CDC Foundation, John Martin Foundation, ASTHO, Zeshan Foundation, and private donors. FB has received speaker fees from Takeda. DL has no conflict of interest.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

ORCID

Francesco Negro https://orcid.org/0000-0003-4046-4806
Sarah Blach https://orcid.org/0000-0002-9252-7576

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SUPPORTING INFORMATION

Additional supporting information may be found in the online version of the article at the publisher's website.

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