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Modelling the health and cost implications of expanded access to HIV, HCV and sexually transmitted infection testing in Switzerland

Harsh Vivek Harkare[ab], Marina Antillon[ab], Axel J. Schmidt[c], Fabrizio Tediosi[abd]

[a] Swiss Tropical and Public Health Institute, Allschwil, Switzerland
[b] University of Basel, Basel, Switzerland
[c] Sigma Research, Department of Public Health, Environments and Society, London School of Hygiene and Tropical Medicine, London, United Kingdom
[d] University of Milan, Milan, Italy

Summary

BACKGROUND: This study was conducted as part of the Swiss National Programme to Stop HIV, Hepatitis B Virus, Hepatitis C Virus and Sexually Transmitted Infections (NAPS), which aims to reduce the spread of sexually transmitted infections in Switzerland. The goal was to identify the most effective and cost-efficient screening strategies to lower the incidence of human immunodeficiency virus (HIV), hepatitis C virus (HCV), syphilis, *Neisseria gonorrhoeae* and *Chlamydia trachomatis* by improving access to screening.

METHODS: A Markov model was developed to assess the impact of various screening strategies among key populations over two years, including men who have sex with men (MSM), female sex workers (FSW) and people who inject drugs (PWID). The model further stratifies individuals based on partner number (MSM) and injection-equipment sharing (PWID). Comprehensive cost estimates for screening and treatment were derived from insurance data, literature and expert opinions. The effectiveness of screening interventions was evaluated by measuring reductions in disease incidence and cost savings, comparing the costs of screening to those of acute and chronic care for prevented infections.

RESULTS: Increased screening frequency among key populations led to a reduction in incidence for all five infections studied. The largest effect was seen in people who inject drugs who share injecting equipment, where HCV incidence fell by up to 76% with four annual screens. However, only screening for HIV, HCV and syphilis proved to be cost-saving. Screening for *Chlamydia trachomatis* and *Neisseria gonorrhoeae* consistently incurred net costs due to the high screening costs and relatively low treatment costs.

CONCLUSION: Targeted expansion of screening among key populations can reduce the incidence of HIV, HCV and syphilis in Switzerland, with regular screening offering potential cost savings to insurers under specific coverage and treatment scenarios.

Harsh Vivek Harkare, MSc
Swiss Tropical and Public Health Institute
Kreuzstrasse 2
CH-4123 Allschwil
harshvivek.harkare[at]swisstph.ch

Introduction

The Swiss National Programme to Stop HIV, Hepatitis B Virus, Hepatitis C Virus and Sexually Transmitted Infections (NAPS) aims to eliminate HIV and HCV transmission and reduce the spread of sexually transmitted infections in Switzerland by 2030 [1]. Previous research has shown that increasing screening frequency can significantly lower the prevalence of certain bacterial sexually transmitted infections in Switzerland, such as syphilis [2]. However, the optimal screening intervals for other sexually transmitted infections, such as *Neisseria gonorrhoeae* and *Chlamydia trachomatis*, remain uncertain. Currently, sexually transmitted infection screening and testing in Switzerland is not covered by compulsory health insurance unless symptoms are present or there is a justified suspicion of infection. HIV testing is covered under provider-initiated counselling and testing (PICT) guidelines, while HCV screening is not covered [3].

With the increasing recognition of asymptomatic sexually transmitted infection transmission, assessing the effectiveness of various screening strategies within the Swiss context has become increasingly important [4]. Previous studies have highlighted the heightened infection risk among specific populations such as men who have sex with men (MSM) and female sex workers (FSW) [5, 6]. In response, NAPS prioritises expanding screening efforts and improving access to testing for at-risk groups. This includes revising testing strategies based on evidence and ensuring equitable access for all, including individuals with limited financial resources.

The present modelling study was conducted with two key objectives: to assess the impact of increased screening frequencies and to provide guidance for official sexually transmitted infection screening recommendations by the Swiss Federal Office of Public Health (FOPH). Currently,

ABBREVIATIONS

FSW	female sex worker
MSM	men who have sex with men
PWID	people who inject drugs

screening guidelines are available only from the Swiss AIDS Federation (Aids-Hilfe Schweiz [AHS]) [7].

The study seeks to identify the most effective screening strategy, considering key populations and optimal screening frequencies to reduce the incidence of HIV, HCV, syphilis, *Neisseria gonorrhoeae* and *Chlamydia trachomatis* in Switzerland. Additionally, it evaluates the economic impact of integrating such a strategy into the Swiss compulsory health insurance benefit package.

Methods

Screening strategies

Screening strategies are determined based on a combination of factors, including key population, type of infection and screening frequency. Following the recommendations outlined by the Swiss AIDS Federation and considering data availability, the study focuses on three key populations:

- men who have sex with men (MSM)
- female sex workers (FSW)
- people who inject drugs (PWID)

MSM and PWID were further subdivided into two subgroups: those at higher risk and those at lower risk of sexually transmitted infections. According to recommendations from the Swiss AIDS Federation, MSM in Switzerland are considered at higher risk if they had 12 or more non-steady partners per year [8]. For PWID, the Swiss Federal Office of Public Health LoveLife campaign defines higher risk of HIV and HCV as having ever shared needles or injection equipment [9].

Screening frequencies for all five infections under study – HIV, hepatitis C virus, syphilis, *Neisseria gonorrhoeae* and *Chlamydia trachomatis* – were modelled based on the behavioural risk level of each target group: individuals at lower risk undergo annual screening, while those at higher risk are screened two to four times per year [7]. All FSW were classified as being at high risk of sexually transmitted infections due to their typically high number of partners.

A significant proportion of pre-exposure prophylaxis (PrEP) users in Switzerland are enrolled in the Swiss PrEPared study, where they undergo frequent screening for sexually transmitted infections [10]. Consequently, pre-exposure prophylaxis users were excluded from our analysis.

We modelled screening for different combinations of key populations and infections based on Swiss AIDS Federation recommendations [7]. Specifically, we simulated the impact of screening for all infections except HCV among MSM and FSW, while for PWID, screening was modelled only for HIV and HCV.

Screening frequencies were defined in increments, starting from a baseline level (0×) and increasing by one additional annual screen up to a maximum of four screens per year (4×). The baseline screening frequency (0×) represents the current status quo of testing within the key populations in Switzerland, without any interventions offering screening at reduced prices. A 1× screening scenario refers to the provision of one annual screen for everyone within a given key population, taking the actual testing uptake rate into account.

Based on the above recommendations, a total of 36 screening strategies were defined and simulated. Additionally, 16 comparator scenarios were established, each representing a baseline screening frequency for each disease and key population, simulating the current observed screening uptake in Switzerland. The modelling conventions for the key populations are as follows: MSM with higher partner numbers (MSM_HR), MSM with lower partner numbers (MSM_LR), female sex workers, people who inject drugs with equipment sharing (PWID_HR) and other PWID (PWID_LR). A list of all simulated screening frequencies is provided in the appendix (table S2).

Modelling approach and outcomes

A Markov model was developed to simulate the impact of increased screening within each target population. The model runs on weekly time steps and comprises four health states: (1) susceptible, untested, (2) susceptible, tested, (3) infected, diagnosed, and (4) infected, undiagnosed, as outlined in figure 1. The transition probabilities for each infection were defined separately and were informed by a variety of data sources as well as published literature as outlined in the appendix. The observed values of the population were fitted to a Dirichlet distribution – a conjugate prior to the multinomial distribution – and sampled 1000 times to incorporate parameter uncertainty.

For each screening strategy, we assessed two primary outcomes:

1. Health benefit: Decrease in incidence of infection in the first and the second year after implementing the expanded screening strategy, as compared to the baseline incidence under the status quo screening frequency.
2. Cost to insurance providers: This will include comparing the cost of screening with the cost of acute- and chronic-care treatment for HIV and HCV, or treatment of severe complications for syphilis, *Neisseria gonorrhoeae* and *Chlamydia trachomatis*.

Healthcare in Switzerland is funded through mandatory basic insurance, with individuals paying monthly premiums and covering medical costs up to a set deductible (franchise). Beyond this, insurance covers expenses minus a copayment, until a maximum out-of-pocket limit is reached. Except for HIV, screening for sexually transmitted infections and HCV is covered by insurance when symptoms are present or an infection is suspected. Otherwise, screening is subject to the deductible, which may discourage access [11].

To assess the cost implications for insurance providers, we analysed two distinct scenarios of insurance coverage: one with and one without the waiver of the deductible component (referred to here as with or without franchise-waiver). The decision to offer screening with or without a franchise-waiver substantially affects the estimated financial burden on insurers, as implementing a franchise-waiver leads to higher costs for them. A screening strategy is considered cost-saving if its total implementation cost is lower than the projected expenses for treating the infections it prevents. Additionally, we assumed that the screening uptake rate remained constant, regardless of whether a franchise-waiver is in place. We considered the full range of deductible thresholds offered in Switzerland (CHF 300

to CHF 2500) for the franchise-waiver scenario. Detailed assumptions on the franchise-level enrolment and insurer cost shares can be found in the appendix.

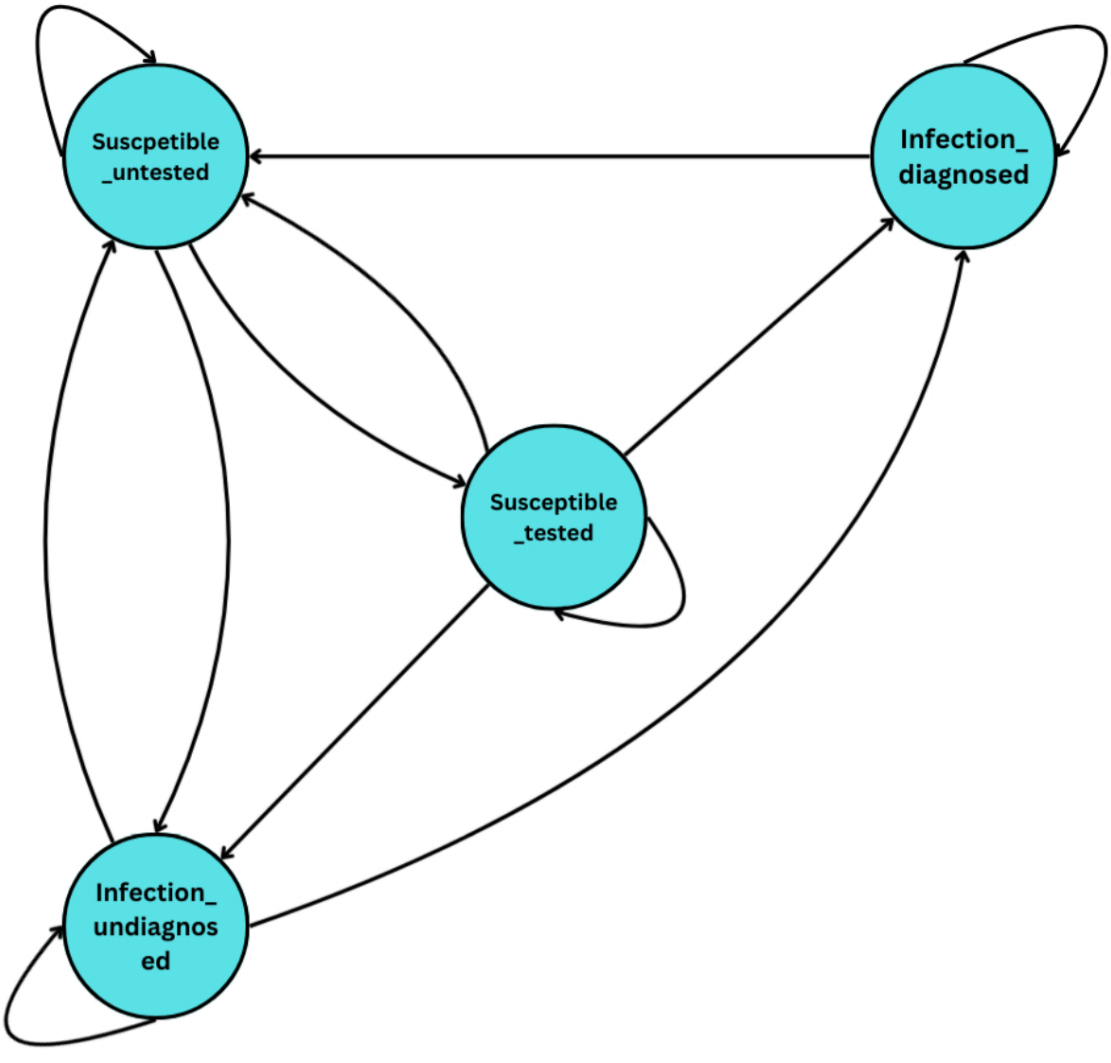
The cost implications to insurance providers under different screening evaluation strategies were assessed in terms of their cost-saving potential. Cost-saving outcomes were evaluated across four scenarios, ordered by increasing cost assumptions: (1) acute treatment with franchise-waiver, (2) acute treatment without franchise-waiver, (3) chronic treatment with franchise-waiver, and (4) chronic treatment without franchise-waiver. This hierarchical structure reflects the logic that if a screening strategy is cost-saving under the most conservative assumption (acute treatment with franchise-waiver), it will also be cost-saving under all less-conservative scenarios. Conversely, if a strategy is only cost-saving under the final scenario (chronic treatment without franchise-waiver), it will not be cost-saving under any of the cheaper evaluation strategies. This framework allows us to assess the robustness of each strategy's cost-saving potential across increasing cost assumptions.

To assess the validity of our model, we compared the model-estimated incidence rates under baseline screening conditions with empirically observed incidence data for key populations, including MSM and FSW.

Data sources

Multiple data sources were used to inform model parameters. Empirical data on screening uptake, test positivity, disease prevalence and risk behaviours were drawn from BerDa, the Swiss STAR trial and EMIS-2017 [5, 12]. BerDa is an electronic tool developed by the Swiss Federal Office of Public Health for history-taking, counselling and recording related to HIV, HCV and sexually transmitted infection [3]. It captures self-reported information on sexual risk, behaviours and previous infections. Additionally, most test centres using BerDa also reported laboratory-confirmed diagnoses of HIV, HCV and sexually transmitted infections. For our analysis, we used BerDa data for one year, from June 2023 to June 2024. The data was collected from 19 voluntary counselling and testing centres

Figure 1: Markov model structure. The model consists of four health states: (1) susceptible and untested, (2) susceptible and tested, (3) infected but undiagnosed, and (4) infected and diagnosed. Individuals can transition between these states on a weekly basis. Not all infections involve all transitions. For example, in the case of HIV, the transition from "Infection, diagnosed" to "Susceptible, untested" is zero, as individuals do not return to an untested susceptible state after diagnosis. Similarly, transition probabilities may differ by infection type depending on natural clearance or treatment efficacy.



across Switzerland, of which only two did not report laboratory-confirmed outcomes. The Swiss STAR trial also provides laboratory-confirmed diagnoses, whereas EMIS-2017 relies on self-reported data.

Additional parameters – such as treatment success and uptake rates, diagnostic sensitivity and specificity, proportion of symptomatic and asymptomatic infections and population estimates – were obtained from published literature. Population estimates were updated to reflect the current year based on Switzerland's overall population growth trend. SWICA provided data on health expenditure and insurance demographic profiles. For model validation, empirically observed incidence rates in Switzerland were taken from the most recent population-specific, laboratory-confirmed incidence estimates available, derived from the Swiss STAR trial, which was conducted in 2017 [5, 6]. Data from the Swiss HIV Cohort Study and Swiss PrEPared could not be obtained. A summary of key model parameters and data sources is presented in table 1, while further details, including a complete list of model parameters and their sources, are provided in appendix table S1.

Health insurance cost estimates

To estimate the cost implications of screening and treatment, we also estimated the cost of a single screening test as well as the costs of acute-care treatment for all five infections, chronic-care treatment for HIV and HCV, and of severe complications of *Neisseria gonorrhoeae*, *Chlamydia trachomatis*, syphilis. The estimated cost of screening is inclusive of the cost of consultation as well as the actual screening cost. Consultation costs for screening for any test include 20 minutes of consultation time with an infection specialist as well as personnel time for blood draw, for preparing the test, and for communicating results to the patient (appendix table S5). The cost of screening is estimated from data from SWICA insurance, which covers 20% of the Swiss population and has data on the actual number of tests undertaken and costs incurred by different test centres. Aggregated SWICA data from 2021–2022 provide information on insured individuals, completed screening tests, and associated costs, stratified by age group and franchise level. The mean and 95% CI of the cost of a single screening test was calculated by aggregating over the age group, franchise and year. In line with approved practices, costs for *Neisseria gonorrhoeae* and *Chlamydia trachomatis* screening include testing from three separate swab sites [13].

The cost of medication and treatment were added to the cost of consultation to obtain the final cost of treating one infection. Treatment and medication costs were derived from the official tariff structure of medical services and from the Swiss Federal Office of Public Health-mandated costs for speciality medical products and services [14, 15]. Treatment guidelines for each infection were taken from the Swiss Society for Infectiology [16].

While the costs used in this analysis are estimated from a macroeconomic societal perspective, we also calculated the costs of treating a single infection – both acute and chronic care. A summary of the screening and treatment costs are tabulated in appendix table S3. The costing methodology and guidelines are further detailed in the tables S4 and S5 in the appendix.

Sensitivity analysis

To assess the robustness of our model results to variations in key input parameters, we ran sensitivity analyses, comparing changes to the status quo values based on the observed data. The choice of these sensitivity analyses was based on the parameters that had the most uncertainty and the greatest potential to influence results, as well as with the least available data:

- a 20% increase in the screening uptake rate;
- a 10% increase in the test-positivity rate;
- a 25% decrease in the onward infection transmission rate.

A detailed description of the modelling methods can be found in the appendix.

Table 1:
Overview of modelling parameters and key data sources. Notes: Exact values for each parameter can be found in appendix table S1.

Parameter category	Parameters	Key data sources
Population size	Size of the populations of men who have sex with men, female sex workers and people who inject drugs	Schmidt & Altpeter (2019) [37]; Vernazza et al. (2020) [6]; Bihl et al. (2021) [35]; UNAIDS [38]
Risk behaviour	Proportion engaging in high-risk behaviour (e.g. multiple partners, equipment sharing)	BerDa EMIS-2017 [39]; Swiss STAR Trial [40]
Disease prevalence	HIV, syphilis, *Neisseria gonorrhoeae*, *Chlamydia trachomatis*, HCV prevalence by group	Bigler et al. (2023) [41]; Schmidt & Altpeter (2019) [37]; Swiss STAR Trial [40]; UNODC [42]
Screening uptake	Proportion tested in past year by infection and risk group	BerDa EMIS-2017 [39]; Expert opinion
Test characteristics	Test-positivity rate and diagnostic sensitivity and specificity by infection	BerDa EMIS-2017 [39]; Nevin et al. (2008) [43]; Park et al. (2020) [44]; Vetter et al. (2020) [45]
Treatment parameters	Treatment uptake and success rates by infection	Expert opinion; Kohler et al. (2015) [46]; Nevin et al. (2008) [43]; Wandeler et al. (2015) [47]
Transmission parameters	Onward infections per untreated case	Garnett et al. (1997, 1999) [48, 49]; Paltiel et al. (2006) [50]; Potterat et al. (1999) [51]
Symptomatology	Proportion of asymptomatic infections	Cui et al. (2024) [52]; ECDC [53]; Maheshwari et al. (2008) [54]; Martin-Sanchez et al. (2020) [56]
Self-clearance (HCV)	Proportion of untreated infections that self-clear	Grebely et al. (2014) [56]

HCV: hepatitis C virus; HIV: human immunodeficiency virus.

Results

Impact on incidence

To validate the Markov transition dynamics of our model, we compared the model-estimated incidence of HIV, syphilis, *Neisseria gonorrhoeae* and *Chlamydia trachomatis* under the baseline status quo screening frequency with the incidence observed in the STAR trial for the key populations of MSM and FSW [5, 6]. Figure 2 presents a comparison of the model-estimated incidence against the observed incidence. Except for *Neisseria gonorrhoeae* in the high-partner-number MSM group, our model accurately estimates the observed incidence. Due to a lack of data on population-representative incidence estimates, we were unable to compare our results for PWID.

Figure 3 illustrates the impact of expanded sexually transmitted infection screening on incidence in Switzerland. As the screening frequency increases, incidence declines across all infections as compared to the baseline incidence under the status quo screening frequency. The most prominent reduction is observed for HCV among high-risk PWID: a 76% decrease with 4× annual screens by year 2.

Among MSM, *Neisseria gonorrhoeae* incidence shows a substantial decline, primarily due to its already high baseline observed incidence. Similarly, HIV also exhibits a significant reduction, largely driven by the high screening uptake rate. This effect is, however, smaller in magnitude as compared to other infections due to its already low prevalence. Screening strategies with 1× annual screening for any infection have a more pronounced effect on incidence reduction, as they target a larger population – MSM with lower partner numbers – whereas higher screening frequencies (2×, 3× and 4×) are limited to MSM with higher partner numbers, a much smaller population.

Among FSW, where observed incidence of *Neisseria gonorrhoeae* and *Chlamydia trachomatis* is high, screening has the greatest impact on reducing incidence for these two infections. Despite the already low HIV incidence in FSW, the high testing uptake rate results in a significant reduction in incidence.

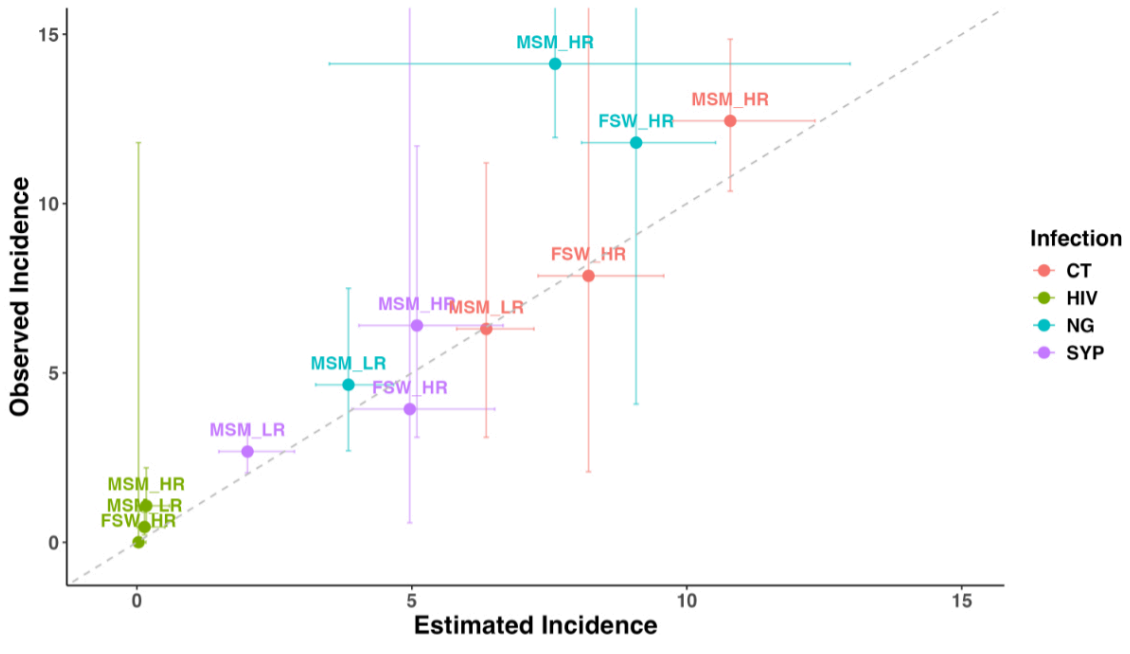
For HCV in PWID, the impact of 1× annual screening is relatively smaller, reflecting the high test-positivity rate among PWID who don't report sharing of drug use equipment. The impact of 1× annual screening on HIV is higher than 2× but smaller than 3× and 4× annual screening because of the larger number of PWID not sharing drug use equipment as well as the low prevalence in the population.

Impact on costs to insurance providers

Figure 4 presents the estimated annual cost savings under different screening strategies by key population from the perspective of insurers. Cost savings are evaluated based on the type of insurance coverage – franchise-waiver or no franchise-waiver – and treatment costs (acute or chronic care). Given that acute-care treatment costs are typically the lowest, cost-savings are more limited under this framework.

Cost-saving outcomes were assessed across four evaluation scenarios, ordered by increasing cost assumptions: (1) acute treatment with franchise-waiver, (2) acute treatment without franchise-waiver, (3) chronic treatment with franchise-waiver, and (4) chronic treatment without franchise-waiver. A strategy deemed cost-saving under a more conservative cost scenario (acute treatment with franchise-

Figure 2: Comparison of model-estimated and observed incidence per 100 person-years. The model-estimated incidence was compared with observed incidence across various populations for *human immunodeficiency virus* (HIV), syphilis (SYP), *Chlamydia trachomatis* and *Neisseria gonorrhoeae*. Observed incidence data was obtained from the Swiss STAR trial. The vertical bars show the 95% confidence intervals of the incidence in the trial (observed incidence) and the horizontal bars show the 95% predictive intervals of our model with re-sampling of parameter values (estimated incidence). FSW: female sex workers; MSM_HR: men who have sex with men with higher partner numbers; MSM_LR: men who have sex with men with lower partner numbers.



waiver) is also considered cost-saving under all scenarios that are more costly to insurance providers. In figure 4, dark green indicates strategies that are cost-saving under the most conservative assumption – acute treatment with franchise-waiver – and thus also under all other evaluation scenarios. Light green reflects strategies that are cost-saving under acute treatment without franchise-waiver and under all subsequent scenarios, but not under the most conservative. Ochre denotes strategies that are cost-saving under both chronic treatment scenarios but not under either acute scenario. Pale yellow indicates strategies that are cost-saving only under the most generous and costly evaluation condition: chronic treatment without franchise-waiver. Red represents strategies that are not cost-saving under any of the four evaluation scenarios.

From a macroeconomic societal perspective, a cost saving is more likely when considering chronic-care costs, as these are generally higher than acute-care costs – except in the case of *Neisseria gonorrhoeae* and *Chlamydia trachomatis*. With a franchise-waiver, insurers bear a larger share of screening costs, making it more challenging for

Figure 3: Percentage decrease in incidence by infection and key population over time. The percentage reduction is estimated for different screening frequencies over a two-year period. In this dumbbell plot, the circle denotes the average reduction in year 1, while the square represents the corresponding reduction in year 2. Annual screening (1×) was available exclusively for men who have sex with men (MSM) and people who inject drugs (PWID) in the low-risk groups, with no 1× screen provided for the female sex workers (FSW) group. In contrast, screening frequencies of 2×, 3× and 4× per year were offered only to MSM and PWID in the high-risk groups and to all FSW. CT: *Chlamydia trachomatis*; HIV: *human immunodeficiency virus*; NG: *Neisseria gonorrhoeae*; SYP: syphilis.

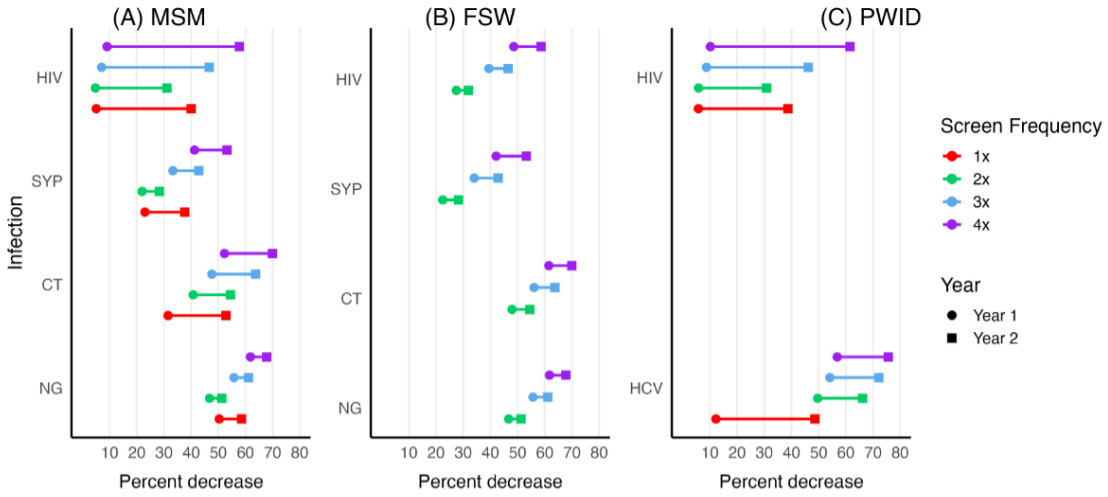
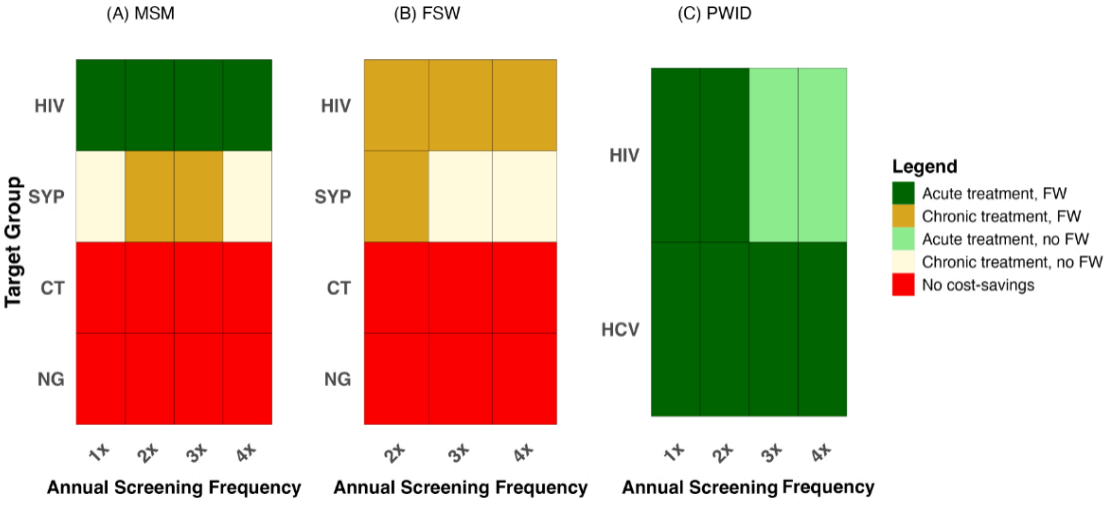


Figure 4: Cost savings under different screening strategies and insurance coverage. Each screening strategy reflects a combination of screening frequency and infection type. Cost savings are shown separately for key populations: (A) men who have sex with men (MSM), (B) female sex workers (FSW) and (C) people who inject drugs (PWID). Estimates are presented across insurance scenarios – with or without a franchise-waiver (FW) – and treatment coverage assumptions (acute or chronic care). Importantly, if a strategy is cost-saving under the "acute treatment, franchise-waiver" scenario, it remains cost-saving under all other, more expensive combinations. In contrast, strategies that are only cost-saving under the "chronic treatment, no franchise-waiver" scenario are not cost-saving in any other case. Red cells indicate strategies that are not cost-saving. All other colours represent cost-saving strategies, classified by cost and insurance assumptions as detailed in the figure legend. Please also note: 1× screening is offered only to low-risk MSM and PWID groups, which represent larger population segments compared to their high-risk counterparts. CT: *Chlamydia trachomatis*; HIV: *human immunodeficiency virus*; NG: *Neisseria gonorrhoeae*; SYP: syphilis.



screening strategies to be cost-saving. Conversely, integrating screening into the health insurance framework without a franchise-waiver would impose a lower financial burden on insurers. Thus, strategies that are cost-saving under the "chronic treatment, no franchise-waiver" scenario are not cost-saving under any other scenario.

Overall, offering 1–4× annual screens to each key population is expected to be cost-saving for HIV, HCV and syphilis at different levels of treatment and insurance coverage. However, for *Neisseria gonorrhoeae* and *Chlamydia trachomatis*, cost savings are not anticipated under any combination of treatment and insurance coverage. These findings were robust under the different sensitivity scenarios conducted.

HIV had the lowest reduction in the absolute number of infections due to its already low prevalence, but the cost of treatment was the highest, thus making it cost-saving. Despite the large reductions in incidence for *Neisseria gonorrhoeae* and *Chlamydia trachomatis*, the high screening costs coupled with relatively low treatment costs make them unlikely to be cost-saving. Detailed results of screening impact on absolute values of infections prevented, screening and treatment costs are shown in the appendix in tables S7–S9.

Table 2 presents the estimated annual cost savings (in thousands of CHF) for each screening strategy, disaggregated by infection, key population, screening frequency and evaluation scenario over one year. Cost-saving potential is greatest for HIV, particularly among MSM with fewer than 12 sexual partners a year (MSM_LR), where annual screening (1×) yields over CHF 261 million in savings under the chronic treatment without franchise-waiver scenario. Substantial savings are also observed for high-frequency screening among MSM_HR and for HCV screening among PWID, especially those not sharing injection equipment. In contrast, screening for *Neisseria gonorrhoeae* and *Chlamydia trachomatis* consistently results in net financial losses, reflecting high screening costs relative to treatment costs. For syphilis, cost savings are modest and scenario-dependent, with benefits observed primarily under more generous cost evaluation assumptions.

Savings are maximised under the chronic treatment without franchise-waiver scenario, which combines high treatment costs with lower insurer contributions to screening. Chronic treatment costs – such as lifelong antiretroviral therapy or HCV-related complications – substantially exceed those of acute care, enhancing the value of prevention. In the absence of a franchise-waiver, screening costs are partially borne by the insured, further reducing the financial burden on insurers. Consequently, strategies that prevent high-cost infections while limiting insurer liability for screening yield the greatest net savings.

However, it is important to note that the acute treatment with franchise-waiver scenario represents the lowest overall cost to insurers, as outlined in the aforementioned hierarchy of scenarios for evaluating cost savings. Interpretation of cost-saving results should therefore be contextualised alongside the absolute screening and treatment costs presented in tables S8 and S9 in the appendix.

Sensitivity analysis

Figure S1 demonstrates that our findings are generally robust to variations in assumptions regarding screening uptake rate, test positivity and onward transmission rate. Among MSM, the results remain unchanged. For FSW, a 10% increase in the test positivity rate renders syphilis screening cost-saving. Likewise, for PWID, a 10% increase in test positivity results in screening becoming cost-saving for HIV under the franchise-waiver scheme.

Discussion

Our model accurately replicates the baseline incidence of the five infections under study at the current screening uptake rate and simulates a reduction in incidence across all key populations with increased screening. The most substantial decline is observed for human immunodeficiency virus (HIV) among men who have sex with men (MSM) and people who inject drugs (PWID) over time. Incorporating screening for HIV, syphilis and hepatitis C virus (HCV) into the health insurance framework is expected to be cost-saving. While screening has a notable impact on the incidence of *Neisseria gonorrhoeae* and *Chlamydia trachomatis*, it is not enough to offset the relatively low treatment cost and the high cost of screening. Therefore, integrating voluntary screening for these infections into the health insurance framework is unlikely to be cost-saving.

Our findings support the implementation of more frequent HIV screening for MSM and female sex workers (FSW), as well as at least biannual screening for people who inject drugs under a franchise-waiver. Although the number of cases prevented annually is relatively small, the associated cost savings are significant. The importance of expanding HIV screening coverage, particularly among vulnerable populations, has been well documented in the literature [17, 18]. Research also emphasises the benefits of frequent annual screenings in reducing incidence and improving viral suppression among people living with HIV, particularly within key populations such as MSM [19, 20]. Additionally, studies underscore the need for increased screening frequency among groups at higher risk within vulnerable populations such as MSM [21].

Similarly, for HCV, our results support the provision of more frequent screening for PWID, aligning with existing literature. Previous studies have highlighted the benefits of expanded general population screening in reducing prevalence and mitigating severe complications for individuals who were infected with contaminated blood products or injectables prior to the discovery of HCV [22, 23]. Since its discovery in 1989, HCV has primarily been transmitted through injectables. As a result, targeted and comprehensive screening strategies, combined with improved access to treatment, have been identified as crucial for eliminating HCV in vulnerable populations such as PWID and MSM living with HIV [24–26]. Importantly, expanded screening among PWID should be implemented in tandem with harm-reduction interventions such as needle and syringe programmes and opioid substitution therapy as these remain the cornerstone of primary prevention efforts [33].

Our study also aligns with findings from a recent modelling study, which showed that expanding screening from once to twice annually among HIV-positive MSM resulted

in a 63.5% reduction in syphilis incidence. In contrast, the same increase in screening frequency among HIV-negative MSM led to a 12.8% reduction in incidence [2]. Similarly, quarterly syphilis screening (four times a year) was found to be the most effective strategy for reducing syphilis incidence among MSM with a high frequency of unprotected intercourse [27].

For *Neisseria gonorrhoeae* and *Chlamydia trachomatis*, although pooled swab testing can help lower screening costs, it would not be sufficient to make the intervention cost-saving, even with a substantial reduction in incidence observed in our results. A more targeted strategy is needed to identify the groups at highest risk within key populations and improve cost-effectiveness by combining focused screening with lower-cost strategies. The evidence in the literature on the effectiveness of *Neisseria gonorrhoeae* and *Chlamydia trachomatis* screening is inconclusive. While a hospital-based screening strategy for rectal *Neisseria gonorrhoeae*/*Chlamydia trachomatis* in MSM led to a 43% reduction in incidence, other studies found no strong evidence that *Neisseria gonorrhoeae* / *Chlamydia trachomatis* screening in MSM significantly impacts disease prevalence, nor that more frequent screening is more effective than annual screening [28, 29]. A randomised controlled trial (RCT) further showed no impact of *Neisseria gonorrhoeae* and *Chlamydia trachomatis* screening on incidence among pre-exposure prophylaxis-using MSM [30]. For *Chlamydia trachomatis* screening in the general population, a separate RCT found a limited impact, suggesting that broad population-based screening may not be an effective strategy for reducing incidence [31]. Moreover, some studies have questioned the clinical rationale

Table 2:
Estimated cost savings by comparing screening costs with treatment costs prevented for different combinations of screening and treatment coverage and screening scenarios over one year.

Infection	Key population	Screening frequency	Estimated cost savings (in thousands of CHF)			
			Acute treatment, franchise-waiver screening	Acute treatment, no franchise-waiver screening	Chronic treatment, franchise-waiver screening	Chronic treatment, no franchise-waiver screening
Human immunodeficiency virus (HIV)	MSM_LR	1×	17,111	19,616	258,818	261,323
	MSM_HR	2×	6,,203	6,940	88,700	89,437
		3×	5967	6,713	86,411	87,157
		4×	5,800	6,550	84,751	85,501
	Female sex workers	2×	−1,447	−493	13,111	14,065
		3×	−1,721	−760	10,411	11,372
		4×	−1,913	−945	8,539	9,507
	PWID_LR	1×	2,013	2,368	32,249	32,604
	PWID_HR	2×	631	737	9,963	10,069
		3×	591	698	9,550	9,657
		4×	566	675	9,339	9,448
Syphilis	MSM_LR	1×	−7,884	−5,221	−3,044	−381
	MSM_HR	2×	−2,225	−1,440	580	1,365
		3×	−2,257	−1,471	142	928
		4×	−2,278	−1,492	−162	624
	Female sex workers	2×	−3123	−2023	702	1,802
		3×	−3171	−2070	88	1,189
		4×	−3,200	−2,098	−342	760
Neisseria gonorrhoeae	MSM_LR	1×	−78,535	−53,125	−78,821	−53,411
	MSM_HR	2×	−24,873	−16,796	−25,039	−16,962
		3×	−26,197	−17,705	−26,334	−17,842
		4×	−26,981	−18,243	−27,099	−18,361
	Female sex workers	2×	−35,072	−23,684	−35,306	−23,918
		3×	−36,945	−24,968	−37,139	−25,162
		4×	−38,045	−25,724	−38,213	−25,892
Chlamydia trachomatis	MSM_LR	1×	−89,210	−60,244	−89,818	−60,852
	MSM_HR	2×	−28,758	−19,411	−28,978	−19,631
		3×	−30,273	−20,448	−30,468	−20,643
		4×	−31,156	−21,053	−31,334	−21,231
	Female sex workers	2×	−36,976	−24,988	−37,183	−25,195
		3×	−38,925	−26,321	−39,100	−26,496
		4×	−40,059	−27,098	−40,213	−27,252
Hepatitis C virus (HCV)	PWID_LR	1×	17,467	19,210	−2,765	−1,022
	PWID_HR	2×	7,259	7,790	−620	−89
		3×	6,675	7,237	−772	−210
		4×	6,281	6,861	−868	−288

MSM_LR = men who have sex with men with less than 12 annual partners

MSM_HR = men who have sex with men with 12 or more annual partners

PWID_LR = people who inject drugs and do not share injecting equipment

PWID_HR = people who inject drugs and share injecting equipment

for screening *Chlamydia trachomatis* infections in general, citing a lack of evidence for preventing long-term sequelae such as infertility, particular in MSM [34].

Notably, many of these studies focused either on general populations, which would have a lower infection prevalence than the groups in our study, or on populations with dense sexual networks, such as MSM on pre-exposure prophylaxis. Our study excludes pre-exposure prophylaxis users from the key populations and thus does not capture the densest segment of the MSM sexual networks. This distinction may explain why our results show a stronger impact of screening in reducing *Neisseria gonorrhoeae* and *Chlamydia trachomatis* prevalence in MSM and FSW who do not use pre-exposure prophylaxis in Switzerland. These two infections are more evenly distributed in the overall general MSM and FSW populations compared to syphilis, which is concentrated among pre-exposure prophylaxis-using and HIV-positive MSM.

Our findings highlight how cost savings from different screening strategies vary not only by infection type and key population but also by the structure of insurance coverage and underlying treatment cost assumptions. A strategy that appears cost-saving under chronic treatment scenarios without a franchise-waiver may not remain cost-saving under more conservative assumptions, such as acute care with a franchise-waiver. This gradient underscores the importance of clearly specifying the evaluation perspective and cost scenario when assessing the financial implications of sexually transmitted infection screening interventions. These distinctions are critical for informing health policy decisions and designing financially sustainable and equitable screening programmes. In addition, while more frequent screening leads to greater reductions in incidence, these benefits occur at increasing cost and with diminishing returns.

Cost savings also depend on the underlying incidence of infection within each key population. For example, HIV screening among MSM remains cost-saving even under more conservative assumptions, such as acute care with a franchise-waiver, whereas the same is not true for FSW. This likely reflects the higher baseline incidence and prevalence of HIV among MSM, which increases the potential for screening to detect and prevent more cases. Thus, the optimal frequency of screening should be determined based on local epidemiology, available resources and programme priorities.

Our study contributes to the growing, albeit small, body of research evaluating the impact of sexually transmitted infection screening on disease incidence in the Swiss context [2, 5, 6]. It is the first to examine this relationship for *Neisseria gonorrhoeae* and *Chlamydia trachomatis* while considering the cost implications for insurance providers. A key strength of our model is the use of a common Markov framework to simulate both viral and bacterial sexually transmitted infections, while accounting for their distinct transmission dynamics and natural histories. Additionally, we provide a comprehensive cost estimate for screening five different sexually transmitted infections in Switzerland, as well as the costs associated with treating both acute and chronic conditions or complications resulting from these infections. Another strength of our approach is the incorporation of risk-behaviour stratification within the defined key populations, enabling a more nuanced analysis of disease dynamics between the two risk groups. Finally, although pre-exposure prophylaxis users were excluded from the analysis, this does not compromise the generalisability of our findings within the non–pre-exposure prophylaxis-using MSM population. While pre-exposure prophylaxis users constitute a small subgroup – less than 7% of the estimated MSM population in Switzerland – with higher sexual risk behaviours and sexually transmitted infection prevalence, they are already systematically screened through established programmes [32]. In contrast, our analysis focuses on expanding access to screening for vulnerable populations with limited access to structured sexually transmitted infection screening.

There are also some limitations to our analysis. First, due to data limitations, we are unable to account for variations in disease dynamics and behaviour within key populations, which may not accurately capture the intragroup differences. Second, we do not consider the site of swabbing for *Neisseria gonorrhoeae* and *Chlamydia trachomatis* screening, which is an important factor, as genital infections are more likely to lead to complications and, therefore, have higher expected treatment costs. Additionally, our assumption that a reduction in the cost of screening, whether offered with or without a franchise-waiver, has the same effect on screening behaviour may not hold. Offering asymptomatic screening without a franchise-waiver through the insurance framework may be more expensive for the test-takers, potentially leading to a lower impact on screening uptake. Finally, we assume a linear relationship between screening frequency and its impact on transition probabilities, due to a lack of data to inform a non-linear relationship, where increasing screening frequency might result in diminishing returns in uptake.

Future research could focus on more specific subgroups, particularly for infections with less evidence, such as *Neisseria gonorrhoeae* and *Chlamydia trachomatis* among HIV-positive or pre-exposure prophylaxis-using MSM. Additionally, future modelling studies may consider the timing of screening, as diagnostic sensitivity varies depending on the duration of infection. Finally, since most decision-making is driven by cost-effectiveness rather than just cost-savings, a comprehensive cost-effectiveness analysis, especially for *Neisseria gonorrhoeae* and *Chlamydia trachomatis*, considering both the costs prevented through case prevention and the quality-of-life improvements from earlier diagnosis and treatment, could provide stronger evidence for the economic efficiency of screening these infections.

Conclusion

Expanding access to screening among key populations in Switzerland can substantially reduce the incidence of HIV, HCV, syphilis, *Neisseria gonorrhoeae* and *Chlamydia trachomatis*. Our model indicates that incorporating regular screening for HIV, HCV and, in selected contexts, syphilis into the national health insurance framework could yield meaningful cost savings for insurers, especially when long-term treatment costs are considered and screening is offered without a franchise-waiver by maintaining deductible thresholds for individuals.

Although our model showed a substantial reduction in *Neisseria gonorrhoeae* and *Chlamydia trachomatis* incidence with increased screening, the high screening costs combined with relatively low treatment costs meant these strategies were not financially viable under the scenarios evaluated. This highlights the potential value of more targeted screening approaches, possibly using finer risk stratifications than applied in this study, and the use of cost-saving diagnostic methods such as pooled testing.

Data sharing statement

The data used in this study was obtained from participating Voluntary Counselling and Testing centres (VCTs) in Switzerland (BerDa) and were provided to the research team under strict data use agreements for the duration of the study. The datasets were deidentified but remain the property of the individual VCTs and were deleted from our systems following completion of the analysis, in accordance with these agreements. As such, we are unable to share the data publicly or upon request. Interested researchers may contact the relevant VCTs directly to enquire about access, subject to their institutional data governance policies and approvals. Data dictionaries and related documents are not publicly available.

Open science statement: This study is a secondary analysis of anonymised data collected through routine sexually transmitted infection testing and service delivery. As it does not constitute a clinical trial, registration in a trial registry was not applicable. Although no formal protocol was prepared, a detailed analysis plan was included in the original funding proposal and shared with both the funders and collaborating data-providing centres. No deviations from this analysis plan occurred.

All analytical code used in the study will be made publicly available via GitHub prior to publication, including details of the software environment, packages and versioning. The code will be released under an open-source licence and linked to in the final manuscript.

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Potential competing interests

All authors have completed and submitted the International Committee of Medical Journal Editors form for disclosure of potential conflicts of interest. No potential conflict of interest related to the content of this manuscript was disclosed.

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Appendix

Modelling methods

Data sources

Since April 2008, most Voluntary Counselling and Testing (VCT) centres in Switzerland have been using the same online system, called "BerDa." This tool is available in German, French, Italian, and English, and has been continuously adapted to meet the needs of participating centres and to support the goals of this study. All data are securely stored in accordance with national and European data protection regulations.

The VCT software operates with two password-protected logins. The first is generated when a VCT centre initiates a new case, using the client's year of birth and postal code area. With this login, clients can anonymously complete an online questionnaire either on a tablet or desktop computer, either in the waiting room or at home before their scheduled visit.

The questionnaire collects detailed information on gender identity and genital characteristics, sexual orientation, sexual history, previous HIV or STI diagnoses, sexual wellbeing, mental health, drug use, as well as risk and preventive behaviours. It also covers the number of sexual partners, STI testing, and vaccination history. Completion typically takes between 10 to 20 minutes.

Table S1. Modelling parameters

Modelling parameters				
Parameter	**Unit**	**Mean**	**SD/Var**	**Source/Explanation**
Risk-behaviour				
MSM_HR (high partner numbers)	%	22.51	6.4630	BerDa
		27.1	0.87	EMIS-2017
		41.9	1.84	Swiss STAR Trial
PWID_HR (sharing drug use equipment)	%	22.41	6.4854	BerDa
Population inputs				
MSM	count	84066		Schmidt & Altpeter, 2019
FSW	count	20699		Bihl *et al.*,(2021), UNAIDS
PWID	count	11034		Bruggman *et al.*, 2017
Disease prevalence				
MSM_HR_HIV	%	8		Schmidt & Altpeter, 2018
MSM_LR_HIV	%	8		Schmidt & Altpeter, 2018
MSM_HR_SYP	%	4.6		Bigler *et al.*, 2023
MSM_LR_SYP	%	4.6		Bigler *et al.*, 2023
MSM_HR_NG	%	3.4		Bigler *et al.*, 2023
MSM_LR_NG	%	3.4		Bigler *et al.*, 2023
MSM_HR_CT	%	12		Bigler *et al.*, 2023
MSM_LR_CT	%	12		Bigler *et al.*, 2023
FSW_HIV	%	0.4		Swiss STAR Trial
FSW_SYP	%	5.9		Swiss STAR Trial
FSW_NG	%	4.9		Swiss STAR Trial
FSW_CT	%	6.3		Swiss STAR Trial

PWID_HIV	%	7.3		UNODC
PWID_HCV	%	42		SHCS
Test-positvity rate				
HIV among HR MSM	%	0.29	0.3158	BerDa
	%	1.1	0.434	EMIS-2017
HIV among LR MSM	%	0.28	0.0389	BerDa
	%	0.4	0.179	EMIS-2017
NG, HR MSM	%	10.52	2.7864	BerDa
	%	13	1.276	EMIS-2017
NG, LR MSM	%	4.85	0.5306	BerDa
	%	2.9	0.383	EMIS-2017
CT, HR MSM	%	7.36	2.297	BerDa
	%	11.6	1.255	EMIS-2017
CT, LR MSM	%	5.54	0.5358	BerDa
	%	2.5	0.357	EMIS-2017
Syphilis, HR MSM	%	7.36	2.8157	BerDa
	%	6.1	0.944	EMIS-2017
Syphilis, LR MSM	%	5.06	0.5077	BerDa
	%	2.2	0.357	EMIS-2017
HIV, FSW	%	0.21	0.1717	BerDa
Syphilis, FSW	%	6.61	2.2878	BerDa
NG, FSW	%	4.81	2.1301	BerDa
CT, FSW	%	5.19	2.7883	BerDa
HIV, HR PWID	%	0	-	BerDa
HIV, LR PWID	%	0	0	BerDa
HCV, HR PWID	%	0	0	BerDa
HCV, LR PWID	%	14.28	17.707	BerDa
HCV, PWID	%	4.5	6.301	EMIS-2017
Onward infection transmission rate				
HIV	Infections	1.44		Paltiel *et al*., 2006
HIV	Infections	2.2043		Nwankwo *et al*., 2017
Syphilis	%	0.627		Garnett *et al*., 1997
Syphilis	Infections	5.6756		Nwankwo *et al*., 2017
NG	Infections	0.35		Garnett *et al*., 1999
CT	Infections	0.55		Potterat *et al*., 1999
HCV	Infections	0.101		Abiodun *et al*., 2022
Multiplier for asymptomatic infections	%	75		Potterat *et al*., 1999
Treatment				
treatment success rate, syphilis	%	95	2.25	Clement *et al*., 2014
treatment success rate, NG	%	93.23	2.25	Allen *et al*., 2013
treatment success rate, CT	%	98	2.25	Lau *et al*., 2002
treatment success rate, CT	%	96	2.6011	Nevin *et al*., 2008

treatment success rate, HCV	%	97.3	2.25	Nguyen *et al.*, 2022
treatment success rate, HCV	%	96	2.25	Beguelin *et al.*, 2017
treatment success rate, HCV	%	78	2.25	Wandeler *et al.*, 2015
treatment success rate, HCV	%	96.5	2.25	Girardin *et al.*, 2019
treatment success rate, HIV	%			
treatment uptake among diagnosed, HIV	%	97	2.25	Kohler *et al.*, 2015
treatment uptake among diagnosed, syphilis	%	95	2.25	Expert opinion
treatment uptake among diagnosed, NG	%	95	2.25	Expert opinion
treatment uptake among diagnosed, CT	%	75	2.25	McCadden *et al.*, 2005
	%	95	2.25	Expert opinion
	%	95	6.3776	Nevin *et al.*, 2008
treatment uptake among diagnosed, HCV	%	77	2.25	Wandeler *et al.*, 2015
	%	35	2.25	SHCS
treatment duration, HIV	weeks	Lifetime		
treatment duration, syphilis	weeks	3		
treatment duration, NG	weeks	1		
treatment duration, CT	weeks	1		
treatment duration, HCV	weeks	10		

Symptoms				
Asymptomatic infections, HIV	%	41.15	7.9224	Cui *et al.*, 2024
Asymptomatic infections, syphilis	%	50.8	2.25	Lang *et al.*, 2018
Asymptomatic infections, NG	%	47.9	3.4158	Martin-Sanchez *et al.*, 2020
Asymptomatic infections, CT	%	60	5.05	ECDC
Asymptomatic infections, HCV	%	80	2.55	Maheshwari *et al.*, 2008
Asymptomatic infections, HCV	%			Busch *et al.*, 2005

Diagnostic tests inputs				
Test sensitivtiy (HIV)	%	99	0.01	BAG
Test specifictiy (HIV)	%	99.5	0.01	BAG
Test sensitivtiy (Syphilis)	%	93.1	5.8088	Park *et al.*, 2020
Test specifictiy (Syphilis)	%	99.8	0.0065	Park *et al.*, 2020
Test sensitivtiy (HCV)	%	91.4	2.5503	Vetter *et al.*, 2020
Test specifictiy (HCV)	%	99.8	0.0653	Vetter *et al.*, 2020
Test sensitivtiy (NG/CT)	%	99	0.0653	Nevin *et al.*, 2008
Test specifictiy (NG/CT)	%	90	6.4581	Nevin *et al.*, 2008

Screening uptake				
HIV, HR MSM	%	85	0.2862	BerDa
HIV, LR MSM	%	69.96	0.0846	BerDa

NG, HR MSM	%	70.7	1.709	EMIS-2017
NG, LR MSM	%	35.6	1.079	EMIS-2017
CT, HR MSM	%	70.7	1.709	EMIS-2017
CT, LR MSM	%	35.6	1.079	EMIS-2017
Syphilis, HR MSM	%	70.7	1.709	EMIS-2017
Syphilis, LR MSM	%	35.6	1.079	EMIS-2017
HIV, FSW	%	65.06	2.5	BerDa
Syphilis, FSW	%	55	2.5	Expert opinion
NG, FSW	%	55	2.5	Expert opinion
CT, FSW	%	55	2.5	Expert opinion
HIV, HR PWID	%	30	2.5	BerDa
HIV, LR PWID	%	55.55	2.5	BerDa
HCV, HR PWID	%	30	2.5	Assumed similar to BerDa
HCV, LR PWID	%	55.55	2.5	Assumed similar to BerDa
		Others		
HCV self-clerance/treatment	%	19.7		Grebely *et al.*2014

Markov model dynamics

The Markov model assumes a steady endemic equilibrium, meaning that, under normal conditions, key outcomes such as infection rates and healthcare costs remain stable over time. When a new policy - such as a screening intervention - is introduced, the system temporarily shifts as it adapts to the change. This adaptation period, or transition phase, occurs over time steps until the model reaches a new stable state.

Since our model operates on weekly time steps, we find that this stabilization typically occurs within the first year (52 weeks). After this point, the system reaches a new steady-state equilibrium, where the key health and cost outcomes no longer fluctuate significantly.

To clearly distinguish between the adjustment phase and the long-term impact of the intervention, we present our results separately:

Year 1: Represents the transition period, where the system adjusts to the policy change.

Year 2: Represent the new steady-state equilibrium, where results remain stable over time.

Markov transition dynamics

Based on the observed data, two baseline transition matrices are defined for each of the five infections studied to simulate the baseline screening scenario based on behavioural factors of that key population – high risk and low risk. The impact of increasing screening frequencies is captured by applying multipliers on the baseline transition matrices. A common set of

multipliers for each of the four screening frequencies is defined based on a combination of observed data and expert opinion. The multipliers are applied to all infections and key populations. However, the variance for HIV and syphilis is defined to be larger than that of the other three infections due to a lack of sufficient data. Additionally, the variance for the high-risk transition matrix is set to be larger than that of the low-risk group.

Risk behaviour calculation

In accordance with AHS guidelines, higher STI risk among MSM is defined as having more than 12 sexual partners per year, and for PWID as having ever shared injecting equipment. Data from the Swiss STAR trial, and EMIS-2017 is used to inform data for this parameter. The data was fit to a beta distribution and sampled 1000 times to estimate the proportion of individuals at higher risk among all MSM and PWID.

Population estimates

The model is fit to 2024 values of the Swiss population for the three key populations of MSM, FSW, and PWID. Population estimates for these key populations are available for MSM from Schmidt & Altpeter, 2019, for FSW from UNAIDS, and PWID from Bruggman *et al*., 2017. The populations are updated to represent the population in the year 2024 based on the annual growth rate of the overall Swiss population as seen from the Federal Statistics Office, 2023. The estimated MSM population using PrEP are excluded from the model, as they are already subject to regular testing in compliance with PrEP regulations.

Modelling scenarios

The 52 modelling scenarios are listed in Table S2. Transition matrices representing the movement between the health states of the Markov model are defined separately for each infection and are applied to all key populations for that infection given the respective infection incidence levels within that key population. This is done due to a lack of data to sufficiently inform the transition matrices specific to each infection and key population.

Table S2. List of modelling scenarios

#	NAME	COMPARATOR SCENARIO
1	MSM_HIV_LR_0x	Yes
2	MSM_HIV_LR_1x	
3	MSM_HIV_HR_0x	Yes

4	MSM_HIV_HR_2x	
5	MSM_HIV_HR_3x	
6	MSM_HIV_HR_4x	
7	MSM_SYP_LR_0x	Yes
8	MSM_SYP_LR_1x	
9	MSM_SYP_HR_0x	Yes
10	MSM_SYP_HR_2x	
11	MSM_SYP_HR_3x	
12	MSM_SYP_HR_4x	
13	MSM_NG_LR_0x	Yes
14	MSM_NG_LR_1x	
15	MSM_NG_HR_0x	Yes
16	MSM_NG_HR_2x	
17	MSM_NG_HR_3x	
18	MSM_NG_HR_4x	
19	MSM_CT_LR_0x	Yes
20	MSM_CT_LR_1x	
21	MSM_CT_HR_0x	Yes
22	MSM_CT_HR_2x	
23	MSM_CT_HR_3x	
24	MSM_CT_HR_4x	
25	FSW_HIV_HR_0x	Yes
26	FSW_HIV_HR_2x	
27	FSW_HIV_HR_3x	
28	FSW_HIV_HR_4x	
29	FSW_SYP_HR_0x	Yes
30	FSW_SYP_HR_2x	
31	FSW_SYP_HR_3x	
32	FSW_SYP_HR_4x	
33	FSW_NG_HR_0x	Yes
34	FSW_NG_HR_2x	
35	FSW_NG_HR_3x	
36	FSW_NG_HR_4x	
37	FSW_CT_HR_0x	Yes
38	FSW_CT_HR_2x	
39	FSW_CT_HR_3x	
40	FSW_CT_HR_4x	
41	PWID_HIV_LR_0x	Yes
42	PWID_HIV_LR_1x	
43	PWID_HIV_HR_0x	Yes
44	PWID_HIV_HR_2x	
45	PWID_HIV_HR_3x	
46	PWID_HIV_HR_4x	
47	PWID_HCV_LR_0x	Yes
48	PWID_HCV_LR_1x	
49	PWID_HCV_HR_0x	Yes

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50    PWID_HCV_HR_2x
51    PWID_HCV_HR_3x
52    PWID_HCV_HR_4x
```

Cost of screening

Confirmatory tests are not included as these are not a focus of the intervention and are already covered by the health insurance. List of screening tests included: HIV-1-p24-antigen rapid test and screening, HCV Ig or IgG screening test, treponema TPHA/TPPA screening test, and PCR test for NG and CT. Cost of screening is derived from data from SWICA, while consultation time cost has been informed by expert opinion.

Table S3. Cost of screening (in CHF)

Infection	Screening cost	Consultation time cost	Total
HIV	20	115	135
SYP	34	115	149
NG	37*3 = 109	115	226
CT	40*3 = 119	115	234
HCV	24	115	139

Table S3 presents the estimated costs of screening, acute-care treatment, and chronic-care treatment for the infections under study. Screening costs per individual are highest for CT at CHF 234, while HIV screening is the least expensive at CHF 135. With pooled swab testing, the cost of screening for NG and CT will fall to CHF 152 and 155, respectively. In terms of acute-care treatment, HIV incurs the highest cost at CHF 19,186, followed by HCV at CHF 15,264. In contrast, syphilis, NG, and CT are significantly less expensive to treat, with costs ranging from CHF 202 to CHF 255.

Cost of treatment

The consultation costs for treating an infection are estimated to be CHF 175. Cost of medication in Switzerland taken from the Specialist list (Spezialitätenliste, 2024). A variety of cost data was observed based on different producers and dosage. This cost data was fit to a log-normal distribution. This distribution was then sampled 1000 times, and the mean and 95% CI of the cost of medication inputted into the model. For the cost of doctor consultation, tax points listed on TARMED are taken 1:1 for conversion to CHF (TARMED, 2018).

Table S4. Treatment guidelines for acute-care treatment of each infection for up to a year.

Infection	Drug	Dosage
HIV	ART	Daily pill for one year
Primary syphilis	B-Penicillin 5ml	2 injections
NG	Ceftriaxone 1g	1 injection
CT	Doxycycline 100 mg	2 daily pills for 7 days
HCV	Maviret (Glecaprevir 100mg)	1 daily pill for 8 weeks

To estimate the expected cost of chronic-care treatment or complications, data on the costs of different health states/complications was combined with the probability of an infected individual achieving that health state/complication. This has been summarised in Table S5.

Averted infections

To estimate infections averted, we use the model-predicted number of infections (diagnosed and undiagnosed) and combine it with data on the average onward infection transmission rate for each of the five infections. These values are presented in Table S1. Weekly transmission rates are derived by dividing the reported transmission rate by the duration of contagion for each infection. For diagnosed infections, the contagion duration is estimated by our model. For undiagnosed infections, the duration of contagion is based on disease epidemiology, presentation of symptoms, and the expected lag in seeking healthcare. In estimating the onward infection transmission rate for different risk profiles, we assumed that individuals in the higher-risk stratum in our model are 20% more infectious than individuals in the lower-risk stratum. The estimated weekly transmission is fit to a normal distribution and sampled 10,000 times to account for uncertainty. The sampled weekly transmission rates for diagnosed and undiagnosed infections are multiplied to the model-estimated number of diagnosed and undiagnosed infections, respectively to get the estimated number of onward new infections. Averted infections are derived by comparing the number of new infections from each screening frequency to that from the baseline screening frequency. We present the percentage decrease in incidence from each successive increase in screening frequency by comparing the averted infections to the baseline annual number of estimated cases.

Cost impact on insurance providers

Data from SWICA from the year 2022 are used to identify the average healthcare expenditure in Switzerland by franchise-level and the share of choice of franchise. Overall, we consider the deductible thresholds of CHF 300, 500, 1000, 1500, 2000, and 2500 for the franchise-waiver scenarios. If a screening policy with franchise-waiver is adopted, insurance providers will be obliged to pay for all screening irrespective of the franchise-level of the insured person. Without a franchise-waiver, we look at the average healthcare expenditure to understand the impact on insurance providers. The insured population in the highest two franchise-levels (CHF 2,000 and CHF 2,500) are the only ones who would not breach their limit by taking up screening according to the average expenditures in 2022. Assuming constant trends for 2024, insurance providers would have to take over the entire cost of screening for those insured in all but these two high-franchise groups. The share of the overall insured population enrolled in these two groups in 2022 was 3% and 32%, respectively. For those insured in these two franchise-groups, any cost of screening under their franchise level will be borne by the payers, and above that level will be borne by the insurance providers. The limit for the 10% co-payment level (the out-of-pocket maximum) was not breached for any franchise-level and has thus been assumed to be borne by the payer when estimating the cost impact to insurance providers.

Model assumptions

The model makes the following assumptions:

(i) Past infection does not affect susceptibility to a subsequent infection

(ii) Screening uptake is constant and equal across key populations

(iii) Treatment uptake is constant and equal across key populations

(iv) No impact of co-infection on costs, transitions between health states, and treatment

(v) Increase in screening uptake rate assumed constant for all screening price reductions, including if offered for free

(vi) Average healthcare expenditure levels stay constant over time

(vii) All infected individuals assumed contagious until treated, except for NG and CT which are assumed to be self-limiting one year after infection

(viii) Key populations follow a similar distribution as the overall Swiss population for selection of choice of insurance franchise

(ix) All individuals spend an amount on healthcare equal to the average (as observed in the SWICA data)

(x) All other healthcare expenditures remain constant

(xi) Population sizes remain constant over time (closed model)

Table S5. Estimated cost of treating chronic-care cases or severe complications from one infection

Expected cost of treating chronic-care and/or complications of one infection			
HIV			
What	**Units**	**Unit cost**	**Source**
Consultation and lab costs for year 1	CHF	4,186	Gueler *et al.*, 2017
Annual medication (ART)	CHF	15,000	Spezialitätenliste
Consultations and all lab costs in the subsequent years (per year)	CHF	1,559	Gueler *et al.*, 2017
Mean duration of ART for HIV+ (years)	Years	42.5	
Total cost year 1, excl comorbidity risk factors	CHF	19,186	
Total annual cost starting year 2, excl comorbidity	CHF	16,559	
Total cost over expected life	CHF	722,928	
HCV			
What	**Units**	**Unit cost**	**Source**
Cost, non-cirrhotic patients	CHF	479	Pfeil *et al.*
% infected reaching non-cirrhotic stage (CHC stage)	%	0.7	WHO
Cost, compensated cirrhosis	CHF	2,715	Pfeil *et al.*
% infected reaching compensated cirrhosis	%	0.15	WHO
Cost, decompensated cirrhosis	CHF	20,347	Pfeil *et al.*
% infected reaching decompensated cirrhosis	%	0.02	WHO
Cost, hepatocellular carcinoma	CHF	16,944	Pfeil *et al.*
% infected reaching hepatocellular carcinoma	%	0.03	El-Serag, 2013
Cost, liver transplant	CHF	125,102	Pfeil *et al.*
% infected needing liver transplant	%	0.012	Ireland *et al.*
Total expected chronic-care cost of one infection	CHF	3,159	
NG			
What	**Units**	**Unit cost**	**Source**
Total cost w/o surgery	CHF	4,800	Kantonsspital Aarau (Barbara Jakopp)
P(infections with complications)	%	0.00625	Dudareva-Vizule *et al.*
Total cost w/surgery	CHF	8,600	
P(infections requiring surgery)	%	0.00047	Sweet, 2020
Total expected chronic-care cost of one infection	CHF	34	
CT			
What	**Units**	**Unit cost**	**Source**
Total cost	CHF	4,800	Kantonsspital Aarau (Barbara Jakopp)

P(infections with complications)	%	0.00625	Assumed similar to NG
Total cost w/surgery	CHF	8,600	
P(infections requiring surgery)	%	0.00047	Assumed similar to NG
Total expected chronic-care cost of one infection	CHF	34	
Syphilis			
What	**Units**	**Unit cost**	**Source**
Total cost, secondary syphilis	CHF	8,600	Kantonsspital Aarau (Barbara Jakopp)
P(infections reaching secondary syp)	%	0.25	Mayo Clinic, 2024
Total cost, tertiary syphilis	CHF	8,600	Kantonsspital Aarau (Barbara Jakopp)
P(infections reaching tertiary syp)	%	0.3	Spach and Ramchandani, 2024
Total cost w/surgery	CHF	8,600	Kantonsspital Aarau (Barbara Jakopp)
P(infections needing surgery)	%	0.025	Assumption (very rare)
Total expected chronic-care cost of one infection	CHF	CHF 4,945	

Table S6. Estimated costs of screening treatment

Infection	Cost of screening	Cost of acute-care treatment	Cost of chronic-care treatment and complications
HIV	135	19,186	722,928
Syphilis	149	255	4,945
NG	226	207	34
CT	234	202	34
HCV	139	15,264	3,159

Note: All costs reflect the expenses associated with screening or treating a single individual. Acute-care treatment refers to treatment lasting up to one year, while chronic-care treatment continues until the infection or its complications are resolved. All costs are in CHF.

Table S6 summarises the cost of screening and acute- and chronic-care treatment. For chronic-care treatment and managing severe complications, the highest costs are associated with HIV at CHF 722,928, reflecting its lifelong reliance on antiretroviral therapy (ART). In contrast, chronic-care costs for NG and CT are the lowest at CHF 34, given their self-limiting nature and low complication rates associated with these infections.

Extended results

The absolute decrease in infections, the cost of screening, and the cost of treatment for acute and chronic care/complications under different screening scenarios is outlined in Tables S7, S8, and S9 respectively. Results from the sensitivity analysis are graphed in Figure S1.

Table S7. Absolute decrease in infections from different screening strategies

Year 1							
Infection	**Key population**	**Screening Frequency**	**Infections averted (mean, 95% CI)**	**Infection**	**Key population**	**Screening Frequency**	**Infections averted (mean, 95% CI)**
HIV	MSM_LR	1x	4 (2–5)	**NG**	MSM_LR	1x	970 (783–1,222)
	MSM_HR	2x	2 (1–2)		MSM_HR	2x	597 (517–714)
		3x	2 (1–2)			3x	721 (639–843)
		4x	3 (1–4)			4x	805 (718–933)
	FSW	2x	2 (1–2)		FSW	2x	843 (730–1,007)
		3x	3 (1–4)			3x	1,017 (901–1,189)
		4x	3 (1–4)			4x	1,136 (1012–1,316)
	PWID_LR	1x	0 (0–0)	**CT**	MSM_LR	1x	1,031 (892–1,273)
	PWID_HR	2x	0 (0–0)		MSM_HR	2x	589 (508–717)
		3x	0 (0–0)			3x	703 (618–835)
		4x	1 (0–1)			4x	780 (691–917)
SYP	MSM_LR	1x	238 (136–429)		FSW	2x	756 (651–919)
	MSM_HR	2x	163 (116–253)			3x	902 (793–1,071)
		3x	248 (194–333)			4x	1,001 (886–1,177)
		4x	307 (246–405)	**HCV**	PWID_LR	1x	30 (21–45)
	FSW	2x	228 (162–355)		PWID_HR	2x	49 (34–68)
		3x	347 (270–467)			3x	56 (40–76)
		4x	431 (343–567)			4x	61 (43–81)
Years 2-5							
Infection	**Key population**	**Screening Frequency**	**Infections averted (mean, 95% CI)**	**Infection**	**Key population**	**Screening Frequency**	**Infections averted (mean, 95% CI)**
HIV	MSM_LR	1x	4 (2–5)	**NG**	MSM_LR	1x	1015 (822–1,284)
	MSM_HR	2x	2 (1–2)		MSM_HR	2x	620 (539–745)

		3x	2 (1–2)			3x	748 (664–878)
		4x	2 (1–2)			4x	836 (745–970)
	FSW	2x	2 (1–2)			2x	875 (761–1,050)
		3x	3 (1–4)		FSW	3x	1,056 (937–1,238)
		4x	3 (1–4)			4x	1,179 (1051–1,368)
	PWID_LR	1x	0 (0–0)		MSM_LR	1x	1,094 (936–1,339)
	PWID_HR	2x	0 (0–0)		MSM_HR	2x	613 (534–754)
		3x	0 (0–0)			3x	732 (648–876)
		4x	0 (0–0)	**CT**		4x	812 (723–962)
	MSM_LR	1x	254 (145–439)			2x	786 (683–965)
	MSM_HR	2x	170 (120–256)		FSW	3x	938 (829–1,122)
		3x	257 (200–342)			4x	1,041 (925–1,232)
SYP		4x	319 (253–417)		PWID_LR	1x	33 (21–48)
	FSW	2x	238 (168–359)	**HCV**	PWID_HR	2x	55 (38–77)
		3x	360 (281–480)			3x	62 (44–85)
		4x	447 (355–584)			4x	67 (49–91)

Table S8. Estimated cost of screening with and without franchise-waiver to insurance providers for different screening scenarios over five years

Year 1								
Infection	**Key population**	**Screening Frequency**	**Screening cost (in thousands CHF)**		**Infection**	**Key population**	**Screening Frequency**	**Screening cost (in thousands CHF)**	
			FW	**No FW**				**FW**	**No FW**
HIV	MSM_LR	1x	7,735	5,230	**NG**	MSM_LR	1x	78,878	53,468
	MSM_HR	2x	2,278	1,541		MSM_HR	2x	25,072	16,995

		3x	2,303	1,557		3x	26,362	17,870
		4x	2,316	1,566		4x	27,123	18,385
	FSW	2x	2,944	1,990		2x	35,353	23,965
		3x	2,969	2,008	FSW	3x	37,178	25,201
		4x	2,988	2,020		4x	38,246	25,925
	PWID_LR	1x	1,096	741	MSM_LR	1x	89,941	60,975
	PWID_HR	2x	329	223		2x	29,023	19,676
		3x	330	223	MSM_HR	3x	30,508	20,683
		4x	336	227	**CT**	4x	31,371	21,268
SYP	MSM_LR	1x	8,233	5,570		2x	37,225	25,237
	MSM_HR	2x	2,428	1,643	FSW	3x	39,136	26,532
		3x	2,430	1,644		4x	40,244	27,283
		4x	2,431	1,645	PWID_LR	1x	5,384	3,641
	FSW	2x	3,399	2,299	**HCV**	2x	1,640	1,109
		3x	3,406	2,305	PWID_HR	3x	1,736	1,174
		4x	3,407	2,305		4x	1,794	1,214

Years 2–5

Infection	Key population	Screening Frequency	Screening cost (in thousands CHF)		Infection	Key population	Screening Frequency	Screening cost (in thousands CHF)	
			FW	No FW				FW	No FW
HIV	MSM_LR	1x	4,988	3,372	**NG**	MSM_LR	1x	77,009	52,201
	MSM_HR	2x	1,686	1,140		MSM_HR	2x	24,981	16,934
		3x	1,743	1,179			3x	26,323	17,843
		4x	1,789	1,210			4x	27,124	18,386
	FSW	2x	2,371	1,603		FSW	2x	35,216	23,872
		3x	2,441	1,651			3x	37,122	25,164
		4x	2,507	1,695			4x	38,257	25,933
	PWID_LR	1x	713	482	**CT**	MSM_LR	1x	87,339	59,211
	PWID_HR	2x	250	169		MSM_HR	2x	28,681	19,444

		3x	255	172			3x	30,224	20,490
		4x	266	180			4x	31,142	21,113
SYP	MSM_LR	1x	3,842	2,600		FSW	2x	37,063	25,127
	MSM_HR	2x	1,761	1,192			3x	39,050	26,474
		3x	1,802	1,219			4x	40,227	27,272
		4x	1,846	1,249	HCV	PWID_LR	1x	4,761	3,220
	FSW	2x	2,474	1,674		PWID_HR	2x	1,501	1,015
		3x	2,539	1,718			3x	1,603	1,084
		4x	2,601	1,760			4x	1,667	1,127

Notes: The figures represent the estimated cost of screening the respective key population by screening frequency. The numbers take into account the observed screening uptake rate. FW = Franchise-waiver

Table S9. Estimated cost of acute-care treatment and treatment of severe complications for different screening scenarios over five years

Year 1									
Infection	**Key population**	**Screening Frequency**	**Treatment cost (in thousands CHF)**		**Infection**	**Key population**	**Screening Frequency**	**Treatment cost (in thousands CHF)**	
			Acute	**Chronic**				**Acute**	**Chronic**
HIV	MSM_LR	1x	24,846	266,553	NG	MSM_LR	1x	343	57
	MSM_HR	2x	8,481	90,978		MSM_HR	2x	199	33
		3x	8,270	88,714			3x	165	28
		4x	8,116	87,067			4x	142	24
	FSW	2x	1,497	16,055		FSW	2x	281	47
		3x	1,248	13,380			3x	233	39
		4x	1,075	11,527			4x	201	33
	PWID_LR	1x	3,109	33,345	CT	MSM_LR	1x	731	123

	PWID_HR	2x	960	10,292		MSM_HR	2x	265	45
		3x	921	9,880			3x	235	40
		4x	902	9,675			4x	215	37
SYP	MSM_LR	1x	349	5,189		FSW	2x	249	42
	MSM_HR	2x	203	3,008			3x	211	36
		3x	173	2,572			4x	185	31
		4x	153	2,269	HCV	PWID_LR	1x	22,851	2,619
	FSW	2x	276	4,101		PWID_HR	2x	8,899	1,020
		3x	235	3,494			3x	8,411	964
		4x	207	3,065			4x	8,075	926

Years 2–5

Infection	Key population	Screening Frequency	Treatment cost (in thousands CHF)		Infection	Key population	Screening Frequency	Treatment cost (in thousands CHF)	
			Acute	Chronic				Acute	Chronic
HIV	MSM_LR	1x	1,938	20,790	NG	MSM_LR	1x	249	41
	MSM_HR	2x	902	9,675		MSM_HR	2x	170	28
		3x	691	7,410			3x	135	23
		4x	557	5,970			4x	111	19
	FSW	2x	1,171	12,556		FSW	2x	240	40
		3x	902	9,675			3x	191	32
		4x	710	7,616			4x	157	26
	PWID_LR	1x	269	2,882	CT	MSM_LR	1x	316	54
	PWID_HR	2x	135	1,441		MSM_HR	2x	151	26
		3x	96	1,030			3x	120	21
		4x	77	824			4x	99	17
SYP	MSM_LR	1x	183	2,720		FSW	2x	194	33
	MSM_HR	2x	149	2,216			3x	154	26
		3x	119	1,768			4x	127	22
		4x	98	1,449	HCV	PWID_LR	1x	3,481	399

FSW	2x	209	3,103	PWID_HR	2x	3,481	399
	3x	167	2,477		3x	2,946	338
	4x	137	2,030		4x	2,580	296

Sensitivity analysis

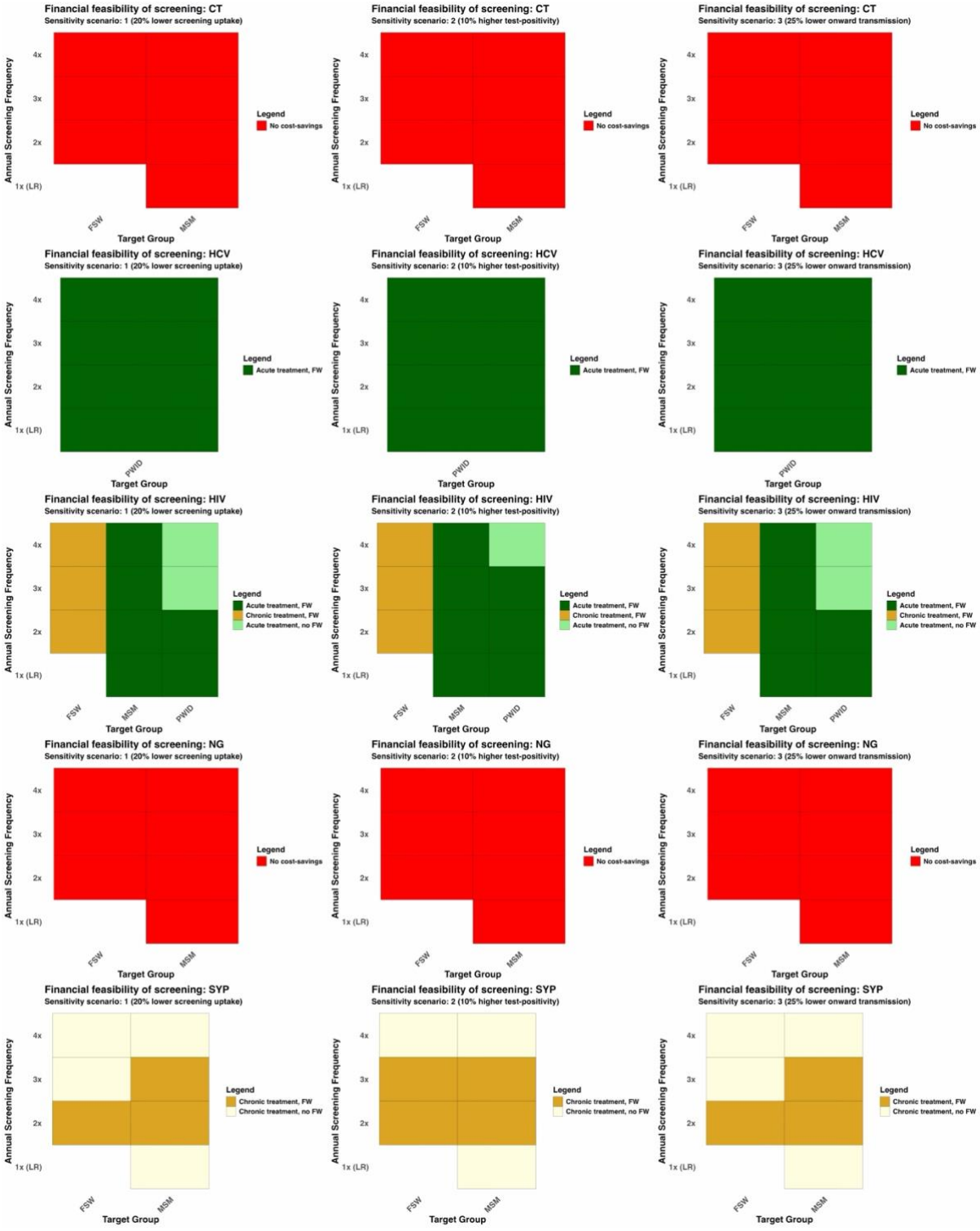

Figure S1. Heatmap of cost savings under different sensitivity scenarios

Note: Screening strategies consist of a combination of screening frequency and infection type. Estimated cost savings are presented for the key populations: (A) men who have sex with men (MSM), (B) female sex workers (FSW), and (C) people who inject drugs (PWID). Cost savings are evaluated based on different insurance scenarios (with or without a franchise-waiver (FW)) and treatment coverage (acute or chronic care). If a strategy is cost-saving under the 'acute

treatment, FW' combination, it remains cost saving across all other combinations. Conversely, strategies that are cost saving under the 'chronic treatment, no FW' combination are not cost saving under any other scenario.

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