Pay-it-forward to increase testing for hepatitis B and C: a community-led randomized controlled trial in China

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Abstract

Hepatitis B virus (HBV) and hepatitis C virus (HCV) testing rates remain low in China, especially among men who have sex with men (MSM). Pay-it-forward involves having a person receive a free test with community-generated messages and then asks if those who received a free test would like to donate money or test to support subsequent other people to also receive free testing. This study aimed to evaluate the capacity of a pay-it-forward strategy with active community participation to promote HBV and HCV testing among MSM in China. We undertook a two-arm superiority cluster-randomized trial led by MSM community-based organizations in two cities in the Jiangsu Province, China. As part of the intervention, MSM peers were actively involved in planning and leading the trial. Enrolled MSM were randomized to the pay-it-forward (intervention) and standard-of-care (control) arms in groups of ten. Men randomized to the pay-it-forward arm received free HBV and HCV testing and were offered a chance to pay-it-forward by donating money to support the testing of another anonymous person. In the standard-of-care arm, each participant paid for their HCV and HBsAg antibody rapid test at US $7.7/test. Only the staff who performed data analyses were blinded. The primary outcome was the proportion of men tested for HBV and HCV. We pre-specified sub-analyses based on substance use, risky sexual behaviors, and people older than 30 years. The trial was registered in the China Clinical Trial Registry (ChiCTR 2100046140). Between March and October 2021, 322 MSM were randomized to the pay-it-forward (n=160) and standard-of-care (n=162) arms. HBV and HCV rapid testing was notably higher in the pay-it-forward arm (59.4%) than in the standard-of-care arm (25.3%) (proportion difference (PD) 34.4%, 95% CI lower bound 26.9%). Sub-analyses demonstrated that the pay-it-forward intervention was effective among people who use substances, people with risky sexual behaviors, and older individuals. Among men in the pay-it-forward arm, 101/160 (63%) donated some amount to future participants, and the total donation amount covered over half (68%) of the test cost in the pay-it-forward arm. Economic evaluation found that the pay-it-forward model was cheaper than the standard of care, considering economic or financial costs per person tested. The pay-it-forward approach improved HBV and HCV testing among an at-risk populations in a resource-constrained environment. Pay-it-forward model appeared to be managed successfully in a real-world setting, especially as a part of community-led efforts to reach higher-risk populations.

Background

The Hepatitis B virus (HBV) and hepatitis C virus (HCV) can cause chronic hepatitis, a major cause of morbidity and mortality globally, especially in Asia (1−3). A mathematical modeling study estimated that, without global intensification to control chronic hepatitis, HBV and HCV infections would cause more deaths by 2040 than the sum of deaths from HIV, malaria, and tuberculosis combined (4). In 2016, the World Health Organization (WHO) set ambitious goals for HBV and HCV elimination by 2030: to diagnose 90% of people with HBV and HCV infections globally, to provide treatment to 80% of people diagnosed, and to achieve a 65% of reduction in related mortality by 2030 (5).

China has a significant HBV and HCV disease burden accounting for 33% and 7% of all infection cases recorded worldwide, respectively (1−3). According to recent WHO data for China, an estimated 87 million people live with chronic HBV, and around 8 million people live with chronic HCV (6). Effective prevention depends upon the regular testing of HBV and HCV among those who test negative and early treatment for those who test positive. With such a large population co-infected with HBV and HCV, researchers have recently advocated for universal HBV and HCV testing among adults in China (7, 8). However, HBV and HCV testing rates in China are far from optimal, with the majority of people with infection being unaware of their infection status (82% for HBV and > 70% for HCV), resulting in missed opportunities to link them to effective treatment (9).
There are several challenges to scaling up HCV and HBV testing in China. First, the cost of testing, especially in the absence of insurance subsidies or coverage, deters people from seeking HBV and HCV testing in Chinese clinics (10). Like many low- and middle-income countries (LMICs), China's primary efforts to control HBV focus on pregnant women and premarital couples to prevent mother-to-child transmission. Free hepatitis testing programs among other populations are limited (1). Second, even when free testing is available in some settings, testing uptake is often low due to hepatitis-related stigma (11, 12). Many people who use drugs and other at-risk groups avoid HBV and HCV testing in public health facilities (13, 14). Until now, hepatitis testing programs have been centralized and focused on clinics within secondary and tertiary hospitals (1, 15, 16). Therefore, an innovative strategy is needed to overcome both person-centered barriers (i.e. testing costs) and system-level barriers (e.g. stigma) hindering people from accessing HBV and HCV testing in China (17).

A pay-it-forward strategy provides a person with an opportunity to receive an anonymous gift, such as HBV and HCV testing, and a chance to pay forward the kindness by anonymously giving a similar offering to another person (18). Implementing a pay-it-forward strategy in community-based organizations (CBOs) has successfully promoted chlamydia and gonorrhea testing among Chinese men who have sex with men (MSM) (19, 20). To date, all studies using the pay-it-forward strategy to promote health services were consistently led by researchers with the help of CBOs for recruitment. However, the impact of the community-led pay-it-forward approach, which empowers community members to be the key actors in the intervention design and implementation, is unclear. Community-led testing services provided by lay health workers outside of traditional hospital settings could help increase testing uptake and overcome system and societal barriers to health services (21, 22). Studies have found that a community-led testing model could attract more untested and higher-risk MSM compared to traditional testing at health facilities (23–25). A community-led pay-it-forward approach may be a promising solution to improve testing uptake and ultimately reduce HBV and HCV transmission among high-at-risk populations like Chinese MSM to reach the national goal of viral hepatitis elimination by 2030 (19, 20). By integrating HBV and HCV testing services within existing community-led HIV testing programs, this study aimed to assess the effectiveness of a community-led pay-it-forward intervention in increasing HBV and HCV testing uptake among MSM in China.

**Results**

A total of 431 people were screened for recruitment from March 2021 to November 2021. Among them, 109 were ineligible for the following reasons: 94 participants had tested for HBV or HCV in the past 12 months, three did not meet inclusion criteria, and 12 did not provide consent (Fig. 1). Overall, 322 MSM, including 160 in the pay-it-forward arm and 162 in the standard-of-care arm, were included in the final analyses. Of these, 241 and 81 were recruited by office-based and outreaching sites, respectively.

Figure 1 shows the trial profile of the participants. The median age of recruited participants was 29 years old (interquartile range [IQR], 25 to 37). Most participants were unmarried (73.6%), highly educated (81.3%), and identified as gay (71.1%). About a third of men (34.5%) self-reported substance use in the previous 12 months. 82% of self-reported substance users used poppers, 2.7% used cannabis, and another 2.7% reported injection drug use. 44.1% of participants were involved in high-risk sexual behaviors in the past three months. Demographic characteristics of participants were similar across the study arms, except that more people use drugs and more men engaged in high-risk sexual behavior in the pay-it-forward arm (Table 1).
Table 1
Descriptive statistics showing the sociodemographic characteristics of MSM participants.

<table>
<thead>
<tr>
<th></th>
<th>Total (N=322)</th>
<th>SC arm (n = 162)</th>
<th>PIF arm (n = 160)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age (median, IQR)</strong></td>
<td>29 (25–37)</td>
<td>30 (25–36)</td>
<td>29 (25–39)</td>
</tr>
<tr>
<td><strong>Education</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Middle school or lower</td>
<td>27 (8.3%)</td>
<td>15 (9.3%)</td>
<td>12 (7.4%)</td>
</tr>
<tr>
<td>High school or technical school</td>
<td>33 (10.3%)</td>
<td>12 (13.6%)</td>
<td>11 (6.7%)</td>
</tr>
<tr>
<td>Undergraduate or above</td>
<td>262 (81.3%)</td>
<td>128 (79.0%)</td>
<td>134 (83.7%)</td>
</tr>
<tr>
<td><strong>Marriage status</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unmarried</td>
<td>237 (73.6%)</td>
<td>116 (71.6%)</td>
<td>121 (75.6%)</td>
</tr>
<tr>
<td>Married or engage</td>
<td>50 (15.5%)</td>
<td>29 (17.9%)</td>
<td>21 (13.1%)</td>
</tr>
<tr>
<td>Divorced or widowed</td>
<td>35 (10.9%)</td>
<td>17 (10.5%)</td>
<td>18 (11.3%)</td>
</tr>
<tr>
<td><strong>Employee</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>263 (81.7%)</td>
<td>130 (80.3%)</td>
<td>133 (83.1%)</td>
</tr>
<tr>
<td>No</td>
<td>59 (18.3%)</td>
<td>32 (19.8%)</td>
<td>27 (16.9%)</td>
</tr>
<tr>
<td><strong>Student</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>54 (16.8%)</td>
<td>28 (17.3%)</td>
<td>26 (16.3%)</td>
</tr>
<tr>
<td>No</td>
<td>268 (83.2%)</td>
<td>134 (82.7%)</td>
<td>134 (83.7%)</td>
</tr>
<tr>
<td><strong>Monthly salary</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(USD)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0-150</td>
<td>34 (10.6%)</td>
<td>18 (11.1%)</td>
<td>16 (10%)</td>
</tr>
<tr>
<td>150–800</td>
<td>103 (32.0%)</td>
<td>53 (32.7%)</td>
<td>50 (31.3%)</td>
</tr>
<tr>
<td>801–1550</td>
<td>123 (38.2%)</td>
<td>64 (39.5%)</td>
<td>59 (36.9%)</td>
</tr>
<tr>
<td>&gt;1550</td>
<td>62 (19.3%)</td>
<td>27 (16.8%)</td>
<td>35 (21.9%)</td>
</tr>
<tr>
<td><strong>Sexual Orientation</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gay</td>
<td>229 (71.1%)</td>
<td>109 (67.3%)</td>
<td>120 (75.0%)</td>
</tr>
</tbody>
</table>

**SC**: standard-of-care; **PIF**: pay-it-forward; **IQR**: interquartile range.

*Sexual risk behaviors include reported engagement in condomless anal sex, group sex, or more than two sexual partners in the preceding three months.
Testing uptake

Overall, 59.4% (95 of 160) of men in the pay-it-forward arm and 25.3% (41 of 162) in the standard-of-care arm received HBV and HCV testing (adjusted proportion difference 34.4%, one-sided 95% CI lower bound 26.9%). The one-sided 95% CI for the absolute proportion difference excluded zero and is much greater than the 20% pre-specified superiority margin (p < 0.001) (Fig. 2).

In addition, among those recruited at the outreach sites, 62.9% (27 of 43) of men in the pay-it-forward arm and 13.1% (5 of 38) of men in the standard-of-care arm received HBV and HCV testing (adjusted proportion difference 51.3%, one-sided 95% CI lower bound 35.5%, p < 0.001). Among those recruited at the office-based sites, 58.1% (68 of 117) of men in the pay-it-forward arm and 29.0% (36 of 124) of men in the standard-of-care arm received HBV and HCV testing (adjusted proportion difference of 29.7%, one-sided 95% CI lower bound 21.3%, p < 0.001).

Across the subgroups defined by high-risk characteristics for HBV or HCV infection, the proportions of MSM testing for HBV and HCV in the pay-it-forward arm were significantly higher by 28.3% – 49.6% than the standard-of-care arm. The most significant increase in testing uptake was among men who had used substances in the last 12 months (adjusted proportion difference 49.6%, one-sided 95% CI lower bound 36.9%, p < 0.001). Similarly, the pay-it-forward intervention was associated with a 43.2% (one-sided 95% CI lower bound 33.6%, p < 0.001) and 32.2% (one-sided 95% CI lower bound 23.9%, p < 0.001) absolute increase in the proportion of men receiving a dual HBV and HCV test among men aged 30 or above and men who had ever engaged in risky sexual behavior in the past three months, respectively. The one-sided 95% suggested that the pay-it-forward intervention was superior to standard-of-care in promoting HBV and HCV testing among all subgroups at a higher risk of HBV and HCV infection (Fig. 2).
The pay-it-forward intervention effects were numerically similar among subgroups at a lower risk of HBV and HCV infection but not superior to standard-of-care. The adjusted absolute proportion differences between the pay-it-forward intervention and standard-of-care arm were: 30.8% among the younger men (one-sided 95% CI lower bound 20.2%); 28.3% among MSM who had never used any substance drug in the last 12 months (one-sided 95% CI lower bound 19.6%); and 31.2% among MSM who had never engaged in risky sexual behavior in the past three months (one-sided 95% CI lower bound 19.7%). Details are in Fig. 2.

**Testing Positivity**

Of the 136 MSM who received testing, ten men (7.4%) tested positive for HBV, among whom six tested through the pay-it-forward arm. Four (3.7%) tested positive for HCV, of whom three tested through the pay-it-forward arm. All positive cases were referred to local hospitals for further diagnostics, treatment, and clinical management. No serious adverse events related to the testing result were observed.

**Economic evaluation**

Among 160 men in the pay-it-forward arm, 63.1% (101/160) chose to donate some amount to the future participants, including 69 (68.3%) men who received HBV and HCV testing and 32 (31.7%) men who did not test. In addition, the proportions of men who donated were similar among men recruited in the outreach and office-based sites (67.4% vs. 61.5%, p = 0.49). The total donation amount was $498.9 among MSM in the pay it forward arm, and the median donation amount per donor was about $3.1 (IQR: 1.5–7.7). The largest donation was $15.4, and the lowest was $1.9. The incremental cost for each treatment arm and the incremental cost-effectiveness ratios (ICERs) based on financial and economic costs, respectively, are shown in Table 2. The pay-it-forward model was more effective and cheaper than the standard-of-care, considering economic or financial costs. The supplementary costs file provides more details on the specific cost and parameters (Supplementary document 2).

<table>
<thead>
<tr>
<th>Treatment group</th>
<th>Economic cost (USD)</th>
<th>Incremental cost</th>
<th>Probability per person tested</th>
<th>Probability per case identified (HBV/ HCV)</th>
<th>ICER (USD per person tested for HBV/HCV)</th>
<th>ICER (USD per case of HBV/HCV identified)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SOC</td>
<td>3.99</td>
<td>-</td>
<td>0.25</td>
<td>0.10</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>PIF</td>
<td>3.78</td>
<td>-0.21</td>
<td>0.59</td>
<td>0.08</td>
<td>Dominated*</td>
<td>10.50</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Treatment group</th>
<th>Financial cost (USD)</th>
<th>Incremental cost</th>
<th>Probability per person tested</th>
<th>Probability per case identified (HBV/HCV)</th>
<th>ICER (USD per person tested for HBV/HCV)</th>
<th>ICER (USD per case of HBV/HCV identified)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SOC</td>
<td>2.04</td>
<td>-</td>
<td>0.25</td>
<td>0.10</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>PIF</td>
<td>0.66</td>
<td>-1.38</td>
<td>0.59</td>
<td>0.08</td>
<td>Dominated*</td>
<td>69.00</td>
</tr>
</tbody>
</table>

*ICER = incremental cost-effectiveness ratio; PIF = pay-it-forward; SOC = standard of care; USD = United States dollars;*

*A dominated strategy is cheaper and more effective than the comparator (SOC).*

**Discussion**
HBV and HCV testing among high-risk populations is the cornerstone of case identification, the gateway to treatment initiation for those with infection, and a crucial prerequisite for the "Treatment as Prevention" strategy to end HBV and HCV epidemics. This study extends the existing literature by integrating a pay-it-forward approach into community-led sexual health service delivery and evaluating its effectiveness in promoting HBV and HCV testing. Our study showed that the community-led pay-it-forward model substantially improved HBV and HCV testing uptake among Chinese MSM compared to the standard-of-care model. In addition, community-led pay-it-forward was effective across different testing modalities and subgroups, especially among men who used substance drugs.

Our study found that a community-led pay-it-forward approach to testing among MSM resulted in substantially increased HBV and HCV testing uptake among Chinese MSM. This finding is similar and consistent with previous intervention studies indicating that pay-it-forward increases testing of sexually transmitted diseases among Chinese MSM who attended sexual health clinics (19, 20). Moreover, a significant strength of our study is the rigorous investigation of the effect of the pay-it-forward approach with notable ‘bottom-up’ community empowerment efforts. Community-led interventions are a critical component of community empowerment. A high level of community participation from study design to implementation ensures our pay-it-forward intervention was contextually appropriate and as inclusive as possible. In addition, empowering community voices in designing tailored service delivery models produced better results. The effect of pay-it-forward on HBV and HCV testing uptake was greater in outreach settings where peer staff provided the testing service more proactively with more flexible services in a gay-friendly environment than waiting for people to present at the CBO. Furthermore, the pay-it-forward approach is known as a way of fostering community engagement (26). A participatory approach like pay-it-forward could generate a warm glow within the community and facilitate increased HBV and HCV testing uptake (18).

We also observed a significantly higher effect of pay-it-forward among MSM who used any substance drugs, which was associated with a 50% increase in testing uptake probability compared to standard-of-care. People who use drugs are a significant group considering they carry higher risk burdens of HBV and HCV and face more significant barriers to testing due to the double stigma associated with their sexual and drug use behaviors (27–29). It was not surprising that testing rates among people who use drugs in the standard-of-care arm were among the lowest across all subgroups. Studies have shown that the pay-it-forward approach with small gifts and generosity can cement community identity. Peer support intervention can also reduce stigma and facilitate health behavior change (30, 31). In addition, a high prevalence of loneliness and social isolation was demonstrated in previous studies among Chinese people who use drugs (31, 32). The findings of our study suggest that the community-led pay-it-forward approach may be particularly effective for marginalized populations, such as people who use drugs. Third, drug use behaviors are often associated with lower socioeconomic status and lack of health insurance which impede the ability of users to seek and access healthcare services (33, 34). This pay-it-forward intervention helped set up a system that allowed accessing healthcare with cheaper costs for financially disadvantaged individuals, which might be another vital facilitator for hepatitis testing uptake among people who use substance drugs.

It is also encouraging that pay-it-forward could be successfully integrated with routine HIV and syphilis testing programs, with all testing provided by trained community staff. Integrating STIs and hepatitis testing with existing HIV testing platforms to improve comprehensive prevention services has been initiated by WHO (35). Such integration can offer health programs the opportunity to increase testing uptake, diagnose co-infections, and address related health conditions simultaneously at the same place. Considering the large number of people who remain unscreened for HBV and HCV in China, future programs could consider integrating pay-it-forward into routine sexual health services to maximize program effectiveness. This could relieve financial constraints and capitalize on opportunities to provide comprehensive services.
Further, about two-thirds of participants (63.1%) who received HBV and HCV testing in the pay-it-forward arm chose to donate some money to support other MSM to get the HBV and HCV tests. Although we did not solicit details on participants' refusal to donate, these donations successfully helped offset the total financial costs for testing participants in the pay-it-forward arm. Critical challenges for programs that hinge upon free or subsidized testing are the high test cost and limited ability to sustain the program in the long run (36). Innovative financing schemes are critical to making affordable health care a sustainable reality for many. The donations collected in the pay-it-forward arm provided a new financing mechanism to fund HBV and HCV testing for key populations by leveraging organizational and individual resources when large-scale government-funded testing is unavailable (20).

The study has several limitations to consider when interpreting the findings. First, blinding the participants or staff who helped recruit participants was impossible due to the nature of the study design. However, the analysts were kept unaware of the study arm allocation. Second, the sample size of this study was prospectively designed to examine the primary outcome in the study population overall. Therefore, some subgroup analyses might have been underpowered, which may have increased the risk of underestimating the differences across subgroups. In addition, to align with previous practice (37), we did not make proper adjustments to correct the potential multiplicity across subgroups. Therefore, our model interpretation focused on estimating the intervention effect within and between subgroups rather than the subgroup-specific p-values to avoid misleading (38). Third, the CBOs in Jiangsu province were heavily occupied during different periods by the influx of COVID-19 patients and related COVID-19 prevention activities. This caused a variation in implementation time across the various study sites. However, when we adjusted for recruitment sites, there was no difference in testing uptake.

Our study has several implications for future implementation and research. First, the encouraging evidence of our study supports integrating a pay-it-forward approach into the existing routine workflow of sexual health services in communities. Community-led service could help improve access to health care services as it is a well-developed method and highly recommended for health interventions among the marginalized population (22, 39). However, community-driven interventions targeting hepatitis testing in China and other LMICs are rare due to the high screening costs and the lack of sustainable funding mechanisms (40, 41). The pay-it-forward approach suggests an innovative way to secure financial resources by leveraging organizational and individual resources for quality community-led hepatitis testing services. Our study also suggests that the community-led pay-it-forward approach could reach and connect populations marginalized from the healthcare system, such as people who use substance drugs, where the majority of the HCV burden lies. This is plausible as studies on community engagement suggest that efforts to build trust and collaboration in a community could help mobilize marginalized or disconnected groups and lead to positive changes in their health behaviors (42, 43). Pay-it-forward principles are driven by a warm sense of community, which may help to sow seeds of social inclusion. Finally, it is noteworthy that the pay-it-forward approach is not an option of last resort to achieve universal access to affordable hepatitis testing in China. On the contrary, the pay-it-forward approach is an effective and de-facto transition strategy that could be put in place to help the community promote HBV and HCV testing when public funding is limited. At the same time, future studies should further explore the potential pathways that can connect these initial programs to the widespread implementation of universal testing.

In summary, the pay-it-forward strategy promoted HBV and HCV testing among the populations at high risk when funding for infectious disease testing among MSM is limited. In addition, to eliminate HBV and HCV by 2030, it is important to get all populations at high risk of HBV and HCV infection tested for HBV and HCV at least once in their life. The findings of our study showed that the proposed pay-it-forward strategy aligned with community-led services
could reach and connect groups usually marginalized from the healthcare system by making healthcare more inclusive, resilient, and affordable.

**Methods**

**Study design**

We conducted a two-arm cluster-randomized controlled trial in Jiangsu Province, a province with one of the highest liver cancer incidences in China. Two cities (Nanjing and Suzhou) were selected for study inclusion given their 1) relatively large MSM populations and 2) presence of at least one MSM-led CBO with experience in providing regular HIV and syphilis testing services for MSM. We selected one MSM-led CBO in each city that provided comprehensive sexual health services (i.e., HIV and syphilis testing, pre- and post-counseling, and care services) for the MSM community by MSM peers.

**Community-led intervention**

Before recruitment, the research team held separate interactive capacity-building sessions to share their knowledge and thoughts on the trial procedures with community staff. The modules for the capacity building workshop included providing information about HBV and HCV testing, rapid testing procedures, data collection, and results reporting. Individuals who had implemented a pay-it-forward approach for other infectious diseases were invited to share their strategies for effective public health messaging, explaining the pay-it-forward process using plain language and promoting donation and engagement. CBO staff were also encouraged to design their tailored operating procedures to ensure that the trial was culturally sensitive and responsive in their local settings.

Initially, The CBO in Suzhou recruited participants through outreach activities in convenient locations with flexible schedules (e.g., gay clubs and KTVs). Secondly, telling real-world pay-it-forward stories about the power of kind actions were applied to improve the connection (Supplementary document 2). The MSM volunteers from the CBOs piloted the study procedures with the research team. These volunteers were committed to all aspects of the pilot study, including ethics, training, engagement strategies, resource management plan, and continuous process monitoring. After the pilot phase, the local public clinic and CBO carried out the designed study independently. Our study’s HBV and HCV testing was conducted with an HIV, syphilis, HCV, and HBsAg multiplex rapid test (Wondfo, Guangzhou, China).

Our study is reported according to the CONSORT guidelines for cluster-randomized controlled trials (Supplementary document 1. CONSORT Checklist).

**Study participants**

Most participants were recruited when they sought HIV or/and syphilis tests at the study or outreach sites. The inclusion criteria included: 1) 18 years old or above; 2) identified as men who have sex with men; 3) neither tested for HBsAg nor HCV antibody in the past 12 months. Men with a chronic HBV or HCV infection diagnosis and those who did not provide informed consent were excluded. In addition, since the HCV vaccine is unavailable in China, even MSM vaccinated for HBV were included in the study, as we used dual HBV and HCV testing.

**Randomization and masking**

This randomized controlled trial (RCT) was designed as a cluster RCT in which a group (cluster) of ten men was randomized into the pay-it-forward or control arms in a 1:1 ratio. We defined a cluster in this study as a group of ten
eligible men who arrived at the study site and agreed to participate. We chose to utilize a cluster randomized trial design for the following reasons. First, participants were recruited from existing HIV/syphilis testing services in real-life settings. Hence, adopting a cluster randomized trial design could help reduce the potential bias due to between-group contamination. Second, it is common during community outreach activities that some men are accompanied by friends to receive tests together. Third, because community staff from each site were primarily responsible for the intervention recruitment and implementation, the implementation of cluster RCT had greater potential to simplify project management and improve adherence to intervention protocols than an individual-based RCT. In addition, many testing behaviors are related to group characteristics. We have used a similar procedure in our previous studies among Chinese MSM (20). Overall, this was a single-blinded cluster RCT, and only the study team member who performed the data analyses was blinded.

**Procedures**

Our study used a two-arm cluster randomized control trial to evaluate the effectiveness of the pay-it-forward intervention model (pay-it-forward arm) against a standard-of-care model (standard-of-care arm) on HBV and HCV testing uptake among MSM. The study recruited participants at one community-led public clinic between 20th August 2021 to 6th November 2021 and from one CBO between March 2021 to October 2021.

Eligible participants were informed about the importance of HBV, HCV testing, and hepatitis transmission routes at enrollment. In the intervention arm, trained MSM peers from the office-based and outreach sites introduced the pay-it-forward concept and shared real-world stories of pay-it-forward with participants at each site. Subsequently, participants were offered HBV and HCV testing as a gift courtesy of the generosity of previous participants, which cost RMB 50 (~7.7 USD) or more at hospitals in China. At the end of the introduction session, each participant (regardless of whether they accepted or rejected testing) could choose to donate any amount of money to support other men in the community to receive the same HBV and HCV tests. All donations were voluntary, with no fixed amounts required. MSM received the same information about HBV and HCV testing in the control arm but needed to pay for their tests (7.7 USD), as is the standard at the clinic.

**Data collection**

In both arms, participants completed a brief, self-administered questionnaire covering socio-demographics, sexual behaviors, previous history of substance use, testing history for HIV, and vaccination history for HBV. A staff of each community-led organization was responsible for the daily reporting of data gathered in a standard administration log, which included the number of participants who gave consent to recruitment, the number of participants who completed HBV and HCV testing, the number of participants in the pay-it-forward arm who donated, and the amount of money donated by participants.

Participants were sub-categorized based on age (>30 years old vs. ≤30 years old), sexual behavior (those involved in any high-risk sexual behaviors in the past three months vs. those not), and history of substance use (used any injection or non-injection recreational drugs in the past 12 months vs. those not). These characteristics are all known to be high-risk factors for HBV or HCV infection (17, 45–48). We defined high-risk sexual risk behaviors as reported engagement in the following: condomless anal sex, group sex, or more than two sexual partners in the preceding three months. One project staff at the Jiangsu CDC updated all outcome data and double-checked with the original records weekly into a secure, password-protected web-based database. The lead investigator responsible for overseeing the research progress had full access to the de-identified data.

**Outcomes**
The primary outcome of this trial was the proportion of men in each arm who tested for HBV and HCV. The dichotomous outcome was determined by HBV and HCV test uptake verified by the CBO members. The secondary outcomes were the proportion of participants who donated to others for HBV and HCV testing and the total amount donated. In addition, the proportion of HBV and HCV testing uptake across each subgroup was compared to determine the heterogeneity in the intervention effect. Furthermore, we compared the cost-effectiveness of the community-led pay-it-forward model to the standard-of-care arm.

**Sample size calculation**

The sample size was calculated based on a superiority cluster randomized trial design. We hypothesize that the community-led pay-it-forward model would increase testing rates more than the standard-of-care model. To detect the differences in testing uptake proportions between the two arms, we estimated the need for 100 participants per arm based on a superiority margin of 0.2 on a one-sided 2.5% level with a power of 80%. The superiority margin of 0.2 for the primary efficacy was considered clinical significance per a previous modeling study (49). In addition, we also increased the sample size by 50% to allow for subgroup analyses of different types of study sites, leading to a sample size of 150 for each arm. Detailed sample size calculation and statistical analysis plan can be found in the study protocol (Supplementary document 3).

**Statistical analysis**

We used descriptive analyses to summarize the sociodemographic and sexual behaviors of participants, donation amount and the proportion of donation of participants. We used a generalized estimating equation model (GEE) with a binomial distribution and an identity link function to estimate the absolute proportion difference as a measure of effect. We adjusted for intraclass confounding factors, including study sites and baseline individual-level covariates (age, sex, education, marital status, income, testing site, and previous HBV vaccination history). Subgroup analyses were performed to investigate the potential effect modification using a relatively simpler model to avoid the problems of collinearity and convergence across the subgroup variable and adjustments (38). Subgroup analyses were based on study site, age, sexual risk behaviors, and substance use patterns. Adjusted absolute proportion differences and corresponding one-sided 95% confidence intervals (CIs) were estimated with a GEE model adjusted for age, sex, education, marital status, income, and recruited cities. All $P$-values reported are one-sided, and $P < 0.05$ was deemed statistically significant. Statistical analyses were performed with STATA software version 14.1 (StataCorp LP, TX, USA).

**Economic evaluation**

We used a micro-costing approach to assess the financial and economic costs (i.e., the cost of all resources needed to implement the testing models) from the perspective of a health provider, the Jiangsu Provincial CDC. We recorded the resources utilized throughout the trial from on-site observation and invoices (Supplementary document 3). The cost items were further classified as fixed or variable. We categorized the start-up (training) and equipment fees as fixed costs (i.e., regardless of the number of tests completed). The cost of supplies used for HBV/HCV testing was considered ‘variable costs (i.e., based on the number of tests completed). All expenses are expressed in USD using OANDA currency conversion rates in 2021 (1 USD = 6.50 Yuan). We conducted a cost analysis in Excel 2019 (Microsoft, USA), and the cost-effectiveness analysis was performed using TreeAge Pro 2021 (TreeAge Software, Inc., Williamstown, MA). This trial was registered with China Clinical Trial (identifier: ChiCTR2100046140) and was reported following the CONSORT 2010 checklist (Supplementary document 1).

**Declarations**


**Ethics statement**

The study was approved by the Jiangsu Center for Diseases Prevention and Control (IRB number JSLK-2020-B014-2). All participants provided written informed consent to participate in the trial before any study-specific procedures. Designated staff at each site confirmed participants’ eligibility and obtained written informed consent. No compensation has provided for participation in the study.

**Data availability**

The data are not publicly available for everyone because making the data publicly available without additional consent or ethical approval might compromise the original ethical approval. If other investigators are interested in performing additional analysis, data requests can be submitted to the corresponding author, explaining the analyses planned.

**Code availability**

All codes are available in Github. The code is freely accessible at https://github.com/PIFHepstudy/code.git

**Acknowledgements**

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**References**


Figures

![Figure 1](image-url)

**Figure 1**
### Number of participants

<table>
<thead>
<tr>
<th></th>
<th>Pay-it-forward n (%)</th>
<th>Standard of care n (%)</th>
<th>Adjusted Probability Difference (one-sided 95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall participants</td>
<td>95 (59.4%)</td>
<td>41 (25.3%)</td>
<td>34.4% (26.9%)</td>
</tr>
<tr>
<td>Study sites</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Public clinic</td>
<td>68 (58.1%)</td>
<td>36 (29.0%)</td>
<td>29.7% (21.3%)</td>
</tr>
<tr>
<td>CBO</td>
<td>27 (62.9%)</td>
<td>5 (13.1%)</td>
<td>51.3% (35.5%)</td>
</tr>
<tr>
<td>Age groups</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>≥30</td>
<td>45 (62.4%)</td>
<td>17 (21.8%)</td>
<td>43.2% (33.6%)</td>
</tr>
<tr>
<td>&lt;30</td>
<td>82 (57.5%)</td>
<td>36 (28.2%)</td>
<td>30.8% (20.2%)</td>
</tr>
<tr>
<td>Ever used any illicit drug in the last 12 months*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>41 (63.1%)</td>
<td>6 (13.0%)</td>
<td>49.6% (36.9%)</td>
</tr>
<tr>
<td>No</td>
<td>54 (56.8%)</td>
<td>35 (30.2%)</td>
<td>28.3% (19.6%)</td>
</tr>
<tr>
<td>Ever involved in any risk behavior in the last 3 months</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>50 (62.5%)</td>
<td>16 (25.8%)</td>
<td>32.2% (23.9%)</td>
</tr>
<tr>
<td>No</td>
<td>45 (55.3%)</td>
<td>25 (25.0%)</td>
<td>31.2% (19.7%)</td>
</tr>
</tbody>
</table>

SC: standard-of-care; PIF: pay-it-forward; IQR: interquartile range.
The overall GEE model was adjusted for age, study sites, education level, income, marital status, and HBV vaccine history. To achieve convergence, subgroup models were adjusted for age, study sites, education level, and income.

* Due to sampling limitation, the substance drug user model was only adjusted for age to achieve convergence.

### Figure 2

**HBV and HCV test uptake rates of two arms**

### Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- [Supplementarydocuments.docx](#)