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Estimating the budget impact of adopting tenofovir/emtricitabine for pre-exposure prophylaxis of HIV in the public health sector in Namibia (2021 – 2023)

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ABSTRACT

Background: Although Namibia started implementing pre-exposure prophylaxis (PrEP) of Human Immunodeficiency Virus (HIV) in 2016, no study to determine its budget impact has been conducted. This study, therefore, aimed to estimate the budget impact of adopting tenofovir/emtricitabine for PrEP of HIV for all eligible people in the public health sector in Namibia from 2021 to 2023.

Methods: A country-specific model was developed for this budget impact analysis (BIA). PrEP has targeted all eligible people in Namibia who receive health services from the public sector. It was assumed that the adherence rate was 75% and PrEP effectiveness 60% in this study. Costs used in this study were taken from a study that included Namibian costs.

Results: The BIA suggests that adopting PrEP may be cost saving as US$104 823, US$143 620, and US$182 452 of additional HIV care costs will potentially be saved in 2021, 2022, and 2023, respectively. Cost savings rely on high adherence rates, high PrEP effectiveness rates, low PrEP costs, and a small number of people living with HIV (PLHIV).

Conclusion: Further economic analysis could aid decision-making in Namibia, both to stress test assumptions in the BIA and conduct cost-effectiveness analysis to estimate the value for money of PrEP.

1. Introduction

From the beginning of the Human Immunodeficiency Virus (HIV) epidemic in 1981, 79.3 million people globally have become infected with HIV as of 2020. By 2020, of the people who got HIV since the beginning of the epidemic, 36.3 million had died from Acquired Immunodeficiency Syndrome (AIDS)-related illnesses, while 37.7 million were living with HIV. In 2020 alone, 1.5 million people became newly infected with HIV globally and 84% of people living with HIV (PLHIV) knew their HIV status. Of the PLHIV who knew their HIV status, 87% were accessing antiretroviral therapy (ART) and among those accessing ART, 90% were virally suppressed [1]. Eastern and Southern Africa carry the most significant burden of the HIV epidemic as 55% of all the PLHIV were in the region in 2020 [1].

Furthermore, almost half of people newly infected with HIV globally were in Eastern and Southern Africa [1]. Namibia, a country whose population is 2.5 million, has 8.3% of its population living with HIV. The HIV incidence rate per year is 0.23% and of the PLHIV in the country, 95% are aware of their status while among those on ART, 92% are virally suppressed [2]. People who do not know their status or know their status but are not yet on treatment, and those who are on treatment but not virally suppressed, are likely to transmit the infection to their partners thereby driving the epidemic [3].

The United States of America President's Emergency Plan for AIDS Relief (PEPFAR) Namibia, provided technical assistance to support the adoption of PrEP in Namibia's national guidelines in 2016. People who were put on PrEP increased from 4702 in

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2018–10,583 in 2019 [2]. The recommended regimens for oral PrEP in Namibia are a daily dose of tenofovir/emtricitabine or tenofovir/lamivudine. The ministry of health and social services (MOHSS) emphasises that PrEP should be offered in combination with other HIV prevention methods like HIV testing, Voluntary Medical Male Circumcision (VMMC), sexually transmitted infections (STI) prevention and management, and providing ART to HIV-positive partners in serodiscordant relationships. Oral PrEP should be offered to any sexually active HIV-negative person at risk of acquiring HIV [5].

According to PrEP guidelines in Namibia, during the first visit for PrEP initiation, a patient should be tested for HIV and taken blood for testing creatinine clearance, hepatitis B surface antigen (HBsAg), and syphilis (Rapid Plasma Reagin). HIV-negative patients are supplied with PrEP for one month, while HIV-positive patients have further tests for ART initiation [5]. The second visit should be done after a month and another HIV test is done and patients are assessed for drug adherence and tolerability. Those adhering to the drugs and tolerating them are then supplied with PrEP drugs for two months [6]. The third visit will be three months after PrEP initiation, and another HIV test is done while tolerability and adherence issues are discussed again. Patients are then given three months supply of PrEP drugs. After the third visit, patients are seen every three months and during each visit, they have an HIV test while creatinine clearance is tested every six months. Although PrEP can be stopped if a person feels that they are no longer at risk, this should be done after 28 days of the last potential exposure to HIV [5].

A scoping review on studies addressing the budget impact of adopting PrEP of HIV for all eligible people did not retrieve any study done in Namibia [7]. This study, therefore, aimed to estimate the budget impact of adopting tenofovir/emtricitabine for PrEP of HIV for all eligible people in the public health sector in Namibia from 2021 to 2023. It was anticipated that the findings would be used to inform the MOHSS on the affordability of implementing PrEP in the public sector. The MOHSS might have also used the data to source funds for the program from international partners.

2. Methods

2.1. Model of analysis

A country-specific model was developed for this BIA, and it was validated by a health economics expert. To analyse the budget impact of tenofovir/emtricitabine, the population that might benefit from the intervention was determined, and this was based on the prevalence of the disease in Namibia [2]. This helped in the calculation of the total costs required to offer PrEP to eligible patients in the public health sector. The analyses were done in Microsoft Excel and were based on assumptions on PrEP effectiveness, coverage of PrEP in the population, and the number of HIV infections likely to be averted.

2.2. Model assumptions and calibration

The MOHSS is responsible for paying for PrEP in the public health sector in Namibia [5]. Reflecting this, the perspective of BIA was taken as that of the MOHSS. The time horizon chosen for BIA studies depends on the length of the budgeting process of the budget holder [8]. Considering that MOHSS has annual budgets, the researcher chose a time horizon of three years, from 2021 to 2023 but reported the BIA of each year separately. Such a short time horizon was selected because the variables used in the BIA model were not expected to have changed significantly within that period. Discounting should be performed in BIA studies that take the medium to long-term time horizons. Discounting is a mathematical procedure used to adjust future costs and outcomes of healthcare interventions to their present value [9]. Since this BIA covered a short time horizon of three years, discounting was not performed.

The effectiveness of tenofovir/emtricitabine for HIV PrEP ranges from about 44% to as high as 100%. The effectiveness is influenced by adherence. Adherence to PrEP is affected by several factors, including stigma, low-risk perception, side effects, and low decision-making power. Adherence can be measured using methods such as self-reports, pill count, electronic methods, and plasma concentration of the drugs [10]. The level of effectiveness of PrEP affects its cost-effectiveness because it determines the number of HIV cases that are prevented [11]. Different studies use different methods to measure adherence, so this made it difficult to have reliable figures for PrEP adherence in Namibia. A study done in Namibia revealed that the adherence rate of patients to anti-hypertensive medications ranged from 55% to 93% [12]. Reflecting this, adherence was assumed to be 75% and effectiveness 60% in this study as these figures were the averages in the studies reviewed and it was also assumed that only those adherent to PrEP would benefit from it.

To estimate the number of PLHIV likely to transmit HIV in the population, data on the number of undiagnosed, patients diagnosed but not yet on treatment, and patients on treatment but not virally suppressed (Viral load > 50 copies/ml) were determined. These data were sourced from PEPFAR [2], and the data presented by PEPFAR were based on the Namibian 2020 Spectrum model, a program used to estimate key HIV indicators for national programmes internationally. The spectrum model's data are considered valid and reliable since they are based on the latest statistics gathered from surveys, censuses and special studies [13]. The estimates on the number of PLHIV likely to transmit HIV in this BIA were based on the 95–95–92 treatment cascade which Namibia is estimated to have reached. This means that 95% of people with HIV in Namibia know their HIV status, 95% are on treatment, and 92% are virally suppressed [1]. A propagation factor can be used to calculate the number of people likely to acquire HIV in the population. This factor is calculated by first estimating the number of PLHIV likely to transmit HIV and the number newly diagnosed with HIV in the population. These numbers are then compared to create a ratio, which is the propagation factor [14].

Since the number of PLHIV likely to transmit in 2021 was 35 526 and the number newly diagnosed with HIV was 5 331 [2], the propagation factor was 6.7:1. This means that for every 67 PLHIV likely to transmit HIV, 10 people would get infected. This propagation factor was used for three years. Since the adherence rate to PrEP was assumed to be 75% and PrEP effectiveness 60%, the number of new infections likely to be prevented through the use of PrEP was calculated by multiplying the number of HIV-negative people likely to acquire HIV by 75% and then by 60%. The number of people likely to acquire HIV with no PrEP was similar to the number of HIV-negative people at risk of acquiring HIV. However, the adoption of PrEP was determined by subtracting the number of new infections likely to be prevented by PrEP from the number of HIV-negative people at risk of acquiring HIV.

About 95% of people in Namibia know their status, and 95% of these will enter HIV [2]. For this BIA, the number of newly infected people likely to enter HIV care in the absence of PrEP was calculated by multiplying the number of HIV-negative people likely to acquire HIV by 95%. The result of this calculation was assumed to be the number of people likely to know their HIV status. This number was again multiplied by 95% to estimate the number likely to enter HIV care. It was assumed in this study that patients already on ART would remain on ART, and mortality was not considered to simplify the model calculations. The number likely to acquire HIV even with PrEP use were assumed to know their HIV status since they underwent HIV test at very visit. To determine the number of newly infected people likely to enter HIV if PrEP was adopted, the number

that acquired HIV when using PrEP was multiplied by 95%, which is the rate of entry into HIV care.

2.3. Budget impact of PrEP

Costs used in this study were taken from a survey that included Namibian prices. The already existing infrastructure was found to be adequate for the PrEP program so no initial capital investment would be required for infrastructure in this BIA. The costs covered training, adherence, demand generation, laboratory tests, personnel, drug, equipment, and facility costs. According to the study, the annual expenses of PrEP per patient are US$236 while HIV care costs per patient are US$673. HIV care costs include preventive therapy like cotrimoxazole prophylaxis, fluconazole prophylaxis, and isoniazid prophylaxis where necessary. Other additional tests in HIV care include CD4 count and viral load monitoring [15]. These costs were used for the three years and the budget impact of PrEP was determined by comparing the total additional costs that MOHSS may incur if PrEP is not adapted to the additional costs that may be incurred if PrEP is adopted.

2.4. Sensitivity analyses

Univariate sensitivity analysis was carried out on the number of PLHIV, PrEP effectiveness, PrEP costs, adherence to PrEP, and ART costs. PrEP effectiveness was considered for sensitivity analysis because the effectiveness has a wide range of 44–100% [10]. Therefore, the number of people who might be prevented from acquiring HIV would vary widely, resulting in considerable differences in the total costs of PrEP and ART. The expenses of PrEP and ART were also considered for sensitivity analyses because these costs can be affected by the introduction of generic drugs into the market and inflation. Furthermore, sensitivity analyses done for similar studies were mainly sensitive to these parameters [14,19–21]. Best-case and worst-case scenarios were also determined and the best-case scenario was created by reducing PLHIV and PrEP costs by 10% while increasing HIV care costs by 10%, PrEP effectiveness increased to 70%, and adherence rate to 85%. In the worst-case scenario, PLHIV and PrEP costs were increased by 10%, while HIV care costs were reduced by 10%, PrEP effectiveness reduced to 50%, and adherence rate to 65%.

3. Results

3.1. Budget impact of PrEP

HIV statistics for Namibia for 2021 used in this BIA are presented in Table 1. Table 1 shows several variables, including the number of PLHIV. Using the 95–95–92 cascade of treatment that Namibia is estimated to have reached, the other variables were computed from the number of PLHIV. The number of people likely to transmit HIV is estimated to be 35 526, while the number of people at risk of acquiring HIV is 5 302. The number of people likely to acquire HIV may reduce from 5 302–2 916, which is a 45% reduction. Lastly, the number of people who acquire HIV who are likely to enter into HIV care without the adoption of PrEP is estimated to be 4 785, while with the adoption of PrEP is 2 770, which may amount to a 42% reduction.

HIV statistics for Namibia for 2021 used in this BIA are presented in Table 2. The figures shown in Table 2 above were calculated assuming that those already on HIV care might continue as before, and there were no deaths in the population. It was also assumed that if there is no adoption of PrEP, all the people who are likely to acquire HIV in 2021 may acquire it while only 2 916 may acquire it if PrEP were adopted. The number of people likely to transmit HIV may amount to 36 452 if no PrEP is adopted, while if PrEP is adopted, it may amount to 36 047. The number of people at risk of acquiring HIV may amount to 5 441 without the adoption of PrEP and 5 380 if PrEP is adopted. The number of people likely to acquire HIV may reduce from 5 441–2 959, which is a 45.6% reduction. Lastly, the number of people who may acquire HIV who will likely enter into HIV care without the adoption of PrEP may amount to 4 911 while with the adoption of PrEP it may amount to 2 811, which is a 42.8% reduction.

HIV statistics for Namibia for 2023 used in this BIA are presented in Table 3. Table 3 shows that the number of people likely to transmit HIV may amount to 37 375 if no PrEP is adopted, while if PrEP is adopted, it may amount to 36 549. The number of people at risk of acquiring HIV may amount to 5 578 without the adoption of PrEP and 5 455 if PrEP is adopted. The number of people likely to acquire HIV may reduce from 5 578–3 000, which is a 46.2% reduction. Lastly, the number of people who may acquire HIV who will likely enter into HIV care without the adoption of PrEP may amount to 5 034, while with the adoption of PrEP it may amount to 2 850, which is a 43.4% reduction.

The budget impact analysis results for the three years are shown in Table 4. BIA results suggest that if PrEP is not adopted in Namibia, MOHSS may need an additional amount of US$3 220 305, US$3 305 103, and US$3 387 882, to provide HIV care for an additional 4 785, 4 911, and 5 034 people who may enter into HIV care in 2021, 2022, and 2023, respectively. However, if PrEP is adopted, the MOHSS may only require an additional amount of US$3 115 482, US$3 161 483, and US$3 205 430, to finance PrEP costs and HIV care for the extra 2 770, 2 811, and 2 850 people who may need to enter into HIV care in 2021, 2022, and 2023, respectively. Adoption of PrEP may save the MOHSS US$104 823, US$143 620, and US$182 452 in 2021, 2022, and 2023, respectively, compared to a situation where PrEP is not adopted. This means the additional costs on HIV care may reduce by 3.3%, 4.3%, and 5.4% in 2021, 2022, and 2023, respectively. Therefore, a 1% increase in cost savings may be realised annually from 2022.

3.2. Sensitivity analyses

The results of the sensitivity analyses are presented in Table 5. Table 5 shows that no cost savings may be achieved if PrEP effectiveness is reduced by 10%. Additional costs of HIV management might increase by 4.6% in 2021. However, the increase may reduce to 3.5% and 2.3% in 2022 and 2023, respectively. In contrast, if PrEP effectiveness is increased by 10%, cost savings may increase by 7.9% in 2021 and 2022, and by 7.7% in 2023. This scenario may be realistic since PrEP effectiveness ranges from 44–100%. An increase in PrEP effectiveness may reduce the number of people acquiring HIV, thereby reducing additional costs on HIV care [17].

If HIV care costs are reduced by 10%, no cost savings may be realised in 2021 and 2022. Additional charges of HIV management may increase by 1.1% in 2021 and 0.1% in 2022. However, cost savings of 1.2% may be realised in 2023. In contrast, if HIV care costs are increased by 10%, cost savings may increase by 3.5% in 2021 and 2022 and by 3.4% in 2023. If PrEP expenses are reduced by 10%, cost savings may increase by 3.8% in 2021 and 2023, and 3.9% in 2022.

On the other hand, if PrEP costs are increased by 10%, no cost savings may be achieved in 2021. In 2021, the prices of HIV management may increase by 0.6%. However, there may be 0.5% and 1.6% cost savings in 2022 and 2023, respectively. These scenarios may be relevant because HIV care and PrEP costs may increase or decrease for several reasons. The costs may increase because of an increase in drug costs due to inflation or lack of competition or an increase in salaries of health care professionals. Furthermore, the costs to MOHSS may decrease due to the introduction of generics, specific agreements with pharmaceutical companies, or subsidisation by international partners [18].

No cost savings may be realised if the PrEP adherence rate is reduced by 10%. There may be additional costs of 4.5% in 2021, which

Table 1
HIV Statistics for Namibia for 2021.

Variable	Source of data and Assumptions	Total for 2021 (With no PrEP)	Total for 2021 (With adoption of PrEP)	Difference (In numbers and percentages)
1. PLHIV	[2]	209 499	209 499	0 (0%)
2. PLHIV knowing their status (95% of PLHIV in 1)	[1] Calculated from PLHIV. It was assumed that 95% of PLHIV knew their status.	199 024	199 024	0 (0%)
3. PLHIV not knowing their HIV status (Number in 1 subtract number in 2)	Difference between number in variable 1 and 2.	10 475	10 475	0 (0%)
4. PLHIV in HIV care (95% of number in 2)	[1] It was assumed that 95% of people who knew their status were in HIV care.	189 073	189 073	0 (0%)
5. PLHIV knowing their status but not in HIV care (Number in 2 subtract number in 4)	Difference between number in variable 2 and 4.	9 951	9 951	0 (0%)
6. PLHIV in HIV care but not virally suppressed (8% of number in 4)	[1] It was assumed that 8% of PLHIV in HIV care were not virally suppressed.	15 126	15 126	0 (0%)
7. PLHIV likely to transmit HIV (Sum of numbers in 3, 5, and 6)	[1] It was assumed that PLHIV who did not know their status, PLHIV who knew their status but were not in HIV care, and PLHIV in HIV care who were not virally suppressed would transmit HIV.	35 526	35 526	0 (0%)
8. People at risk of acquiring HIV (Using propagation ratio of 6.7:1, number in 7 is divided by 6.7)	[14] It was assumed that the ratio of people likely to transmit HIV and the incidence of HIV in 2021 would be the propagation factor.	5 302	5 302	0 (0%)
9. People likely to adhere to PrEP (At 75% adherence rate, number in 8 is multiplied by 75%)	[12]	–	3 977	–
10. People unlikely to acquire HIV due to PrEP (Using 60% effectiveness, number in 9 is multiplied by 60%)	[16]	–	2 386	–
11. People likely to acquire HIV (Number in 8 subtract number in 10)	Difference between number in variable 8 and 10.	5 302	2 916	2 386 (45%)
12. People who acquire HIV who are likely to enter into HIV care (95% multiplied by 95% multiplied by number in 11 for no PrEP or 95% multiplied by number in 11 for with PrEP column)	[1] It was assumed that 95% of people who are likely to acquire HIV will know their status with no PrEP while 100% will know their status if PrEP was adopted. It was also assumed that 95% of people who acquire HIV and know their status will enter into HIV care	4 785	2 770	2 015 (42%)

Table 2
HIV Statistics for Namibia for 2022.

Variable	Source of data and Assumptions	Total for 2022 (With no PrEP)	Total for 2022 (With adoption of PrEP)	Difference (In numbers and percentages)
1. PLHIV	[2]	214 801	212 415	2 386 (1.1%)
2. PLHIV knowing their status (95% of PLHIV in 1)	[1] Calculated from PLHIV. It was assumed that 95% of PLHIV knew their status.	204 061	201 794	2 267 (1.1%)
3. PLHIV not knowing their HIV status (Number in 1 subtract number in 2)	Difference between number in variable 1 and 2.	10 740	10 621	119 (1.1%)
4. PLHIV in HIV care (95% of number in 2)	[1] It was assumed that 95% of people who knew their status were in HIV care.	193 858	191 704	2 154 (1.1%)
5. PLHIV knowing their status but not in HIV care (Number in 2 subtract number in 4)	Difference between number in variable 2 and 4.	10 203	10 090	113 (1.1%)
6. PLHIV in HIV care but not virally suppressed (8% of number in 4)	[1] It was assumed that 8% of PLHIV in HIV care were not virally suppressed.	15 509	15 336	173 (1.1%)
7. PLHIV likely to transmit HIV (Sum of numbers in 3, 5, and 6)	[1] It was assumed that PLHIV who did not know their status, PLHIV who knew their status but were not in HIV care, and PLHIV in HIV care who were not virally suppressed would transmit HIV.	36 452	36 047	405 (1.1%)
8. People at risk of acquiring HIV (Using propagation ratio of 6.7:1, number in 7 is divided by 6.7)	[14] It was assumed that the ratio of people likely to transmit HIV and the incidence of HIV in 2021 would be the propagation factor.	5 441	5 380	61 (1.1%)
9. People likely to adhere to PrEP (At 75% adherence rate, number in 8 is multiplied by 75%)	[12]	–	4035	–
10. People unlikely to acquire HIV due to PrEP (Using 60% effectiveness, number in 9 is multiplied by 60%)	[16]	–	2 421	–
11. People likely to acquire HIV (Number in 8 subtract number in 10)	Difference between number in variable 8 and 10.	5 441	2 959	2 482 (45.6%)
12. People who acquire HIV who are likely to enter into HIV care (95% multiplied by 95% multiplied by number in 11 for no PrEP or 95% multiplied by number in 11 for with PrEP column)	[1] It was assumed that 95% of people who are likely to acquire HIV will know their status with no PrEP while 100% will know their status if PrEP was adopted. It was also assumed that 95% of people who acquire HIV and know their status will enter into HIV care	4 911	2 811	2 100 (42.8%)

Table 3
HIV Statistics for Namibia for 2023.

Variable	Source of data and Assumptions	Total for 2023 (With no PrEP)	Total for 2023 (With adoption of PrEP)	Difference (In numbers and percentages)
1. PLHIV	[2]	220 242	215 374	4 868 (2.2%)
2. PLHIV knowing their status (95% of PLHIV in 1)	[1] Calculated from PLHIV. It was assumed that 95% of PLHIV knew their status.	209 230	204 605	4 625 (2.2%)
3. PLHIV not knowing their HIV status (Number in 1 subtract number in 2)	Difference between number in variable 1 and 2.	11 012	10 769	243 (2.2%)
4. PLHIV in HIV care (95% of number in 2)	[1] It was assumed that 95% of people who knew their status were in HIV care.	198 769	194 375	4 394 (2.2%)
5. PLHIV knowing their status but not in HIV care (Number in 2 subtract number in 4)	Difference between number in variable 2 and 4.	10 461	10 230	231 (2.2%)
6. PLHIV in HIV care but not virally suppressed (8% of number in 4)	[1] It was assumed that 8% of PLHIV in HIV care were not virally suppressed.	15 902	15 550	352 (2.2%)
7. PLHIV likely to transmit HIV (Sum of numbers in 3, 5, and 6)	[1] It was assumed that PLHIV who did not know their status, PLHIV who knew their status but were not in HIV care, and PLHIV in HIV care who were not virally suppressed would transmit HIV.	37 375	36 549	826 (2.2%)
8. People at risk of acquiring HIV (Using propagation ratio of 6.7:1, number in 7 is divided by 6.7)	[14] It was assumed that the ratio of people likely to transmit HIV and the incidence of HIV in 2021 would be the propagation factor.	5 578	5 455	123 (2.2%)
9. People likely to adhere to PrEP (At 75% adherence rate, number in 8 is multiplied by 75%)	[12]	–	4 091	–
10. People unlikely to acquire HIV due to PrEP (Using 60% effectiveness, number in 9 is multiplied by 60%)	[16]	–	2 455	–
11. People likely to acquire HIV (Number in 8 subtract number in 10)	Difference between number in variable 8 and 10.	5 578	3 000	2 578 (46.2%)
12. People who acquire HIV who are likely to enter into HIV care (95% multiplied by 95% multiplied by number in 11 for no PrEP or 95% multiplied by number in 11 for with PrEP column)	[1] It was assumed that 95% of people who are likely to acquire HIV will know their status with no PrEP while 100% will know their status if PrEP was adopted. It was also assumed that 95% of people who acquire HIV and know their status will enter into HIV care	5 034	2 850	2 184 (43.4%)

Table 4
Budget impact of PrEP.

	Total	Unit cost/person/year (US$)	Total additional costs to budget (US$)
Budget Impact of PrEP in 2021			
1. PLHIV entering into HIV care without adoption of PrEP	4 785	673	3 220 305
2. PLHIV entering HIV care with adoption of PrEP	2 770	673	1 864 210
3. People getting PrEP (Number in 8 in above table)	5 302	236	1 251 272
4. Total HIV costs with adoption of PrEP (Add costs in 2 to those in 3)			3 115 482
5. Budget Impact (Difference between costs in 1 and those in 4)			**(104 823)**
6. Budget Impact (%)			**(3.3)**
Budget Impact of PrEP in 2022			
1. PLHIV entering into HIV care without adoption of PrEP	4 911	673	3 305 103
2. PLHIV entering HIV care with adoption of PrEP	2 811	673	1 891 803
3. People getting PrEP (Number in 8 in above table)	5 380	236	1 269 680
4. Total HIV costs with adoption of PrEP (Add costs in 2 to those in 3)			3 161 483
5. Budget Impact (Difference between costs in 1 and those in 4)			**(143 620)**
Budget Impact (%)			**(4.3)**
Budget Impact of PrEP in 2023			
1. PLHIV entering into HIV care without adoption of PrEP	5 034	673	3 387 882
2. PLHIV entering HIV care with adoption of PrEP	2 850	673	1 918 050
3. People getting PrEP (Number in 8 in above table)	5 455	236	1 287 380
4. Total HIV costs with adoption of PrEP (Add costs in 2 to those in 3)			3 205 430
5. Budget Impact (Difference between costs in 1 and those in 4)			**(182 452)**
Budget Impact (%)			**(5.4)**

may reduce to 1.9% in 2022 and 0.8% in 2023. In contrast, if the adherence rate is increased by 10%, cost savings may increase by 6.3% in 2021 and 2022, and by 6.2% in 2023. These scenarios may be relevant because adherence rates to chronic medication in Namibia have a wide range, and adherence is affected by several factors. If the adherence rate is low, the number of people acquiring HIV will increase, thereby increasing the HIV care costs, leading to lower or no cost savings. However, if the adherence rate increases, the number of people acquiring HIV will decrease, thereby reducing the costs of HIV care, leading to higher cost savings [10].

Cost savings may remain the same if the number of PLHIV is varied by 10%. This scenario may be relevant in the country because the number of PLHIV being used may be inaccurate due to errors during data collection and a decrease in the number of PLHIV due to mortality [4]. The best-case scenario may increase cost savings to 25.6% in 2021, 26.4% in 2022, and 27.2% in 2023. The worst-case scenario may increase additional costs of HIV management by 18.5% in 2021, 17.2% in 2022, and 15.9% in 2023. These scenarios were determined to help the MOHSS realise the uncertainties that might be expected if they decide to adopt PrEP.

4. Discussion

The results of this BIA showed that adopting PrEP for HIV in the public health sector in Namibia may be cost saving from the first year of adoption. The cost savings may increase by about 1% each year from the second year of adoption to the third year. The cost savings may result from a decreasing number of people likely to acquire HIV with the introduction of PrEP, and lower PrEP costs compared to HIV care costs. With a smaller number of people likely to acquire HIV, there may be an expected smaller number of people likely to enter HIV care. Although some similar studies have shown that adopting PrEP may be cost saving, the duration required to reach the breakeven point and save costs varied. A study that predicted cost savings within three years of adoption of PrEP was conducted in Colombia [19]. Another study conducted in South Africa among adolescent girls and young women revealed that PrEP was cost-saving compared to a situation where PrEP was not offered [22].

The differences between the duration within which PrEP might be cost saving may be due to the differences in the costs of HIV care, PrEP costs, and the number of people likely to be initiated on PrEP. Since Namibia's PrEP costs are much lower than in the countries where some studies were conducted, this may have contributed to the realisation of a favourable budget impact within the first year following PrEP adoption. Furthermore, the number of people who may be eligible for PrEP in Namibia is much smaller than in the other countries, as it has a smaller population.

After an increase in PrEP effectiveness, HIV care costs, adherence rate, or a reduction in PrEP costs, the BIA of PrEP in Namibia may remain favourable. However, it was more sensitive to PrEP effectiveness, which is to some extent affected by the level of adherence of patients to PrEP drugs [10]. Therefore, if adherence to PrEP is low among patients in Namibia, PrEP effectiveness may also reduce, resulting in smaller cost-saving amounts or even an unfavourable BIA. Using this novel BIA model, for the BIA to remain favourable, MOHSS may need to ensure that the adherence rate of PrEP is maintained above 70%. Drug resistance is another challenge of low adherence, which may affect costs. If patients acquire HIV while on PrEP and continue taking their PrEP drugs due to a lack of knowledge about their status, they are more likely to develop drug resistance to first-line ART drugs [23]. This will lead to them being initiated on second-line drugs which are more expensive [24], resulting in additional costs to the MOHSS. Sensitivity analysis results were also encouraging since they showed that the BIA might remain favourable even with a 10% increase in HIV care costs. This is important because this shows that even with additional increases in HIV drug costs, and salaries of personnel, the MOHSS may still save additional costs on HIV management if PrEP were adopted.

The study had several limitations. It relied on costs determined using a single survey of the costs done in Namibia. These costs might not have reflected the costs required for HIV care and PrEP. The adherence rate for PrEP used in the study was that of anti-hypertensive medications since that of PrEP could not be found. The other limitation is that the MOHSS perspective was taken in this novel BIA. This narrow budget holder perspective might have missed some costs and savings that might be incurred by other stakeholders such as patients, other government ministries, and international partners. Ignoring these costs might have influenced the results of the novel BIA, thereby providing a more robust investment case. However, if the actual budget impact were unfavourable, this would lead to an increase in the MOHSS budget or diversion of funds from other services.

Table 5
Sensitivity analyses results.

	Amounts in US$		
	2021	**2022**	**2023**
Budget impact with 50% PrEP effectiveness			
Total additional cost of HIV care with no PrEP	3 220 305	3 305 103	3 387 882
Total additional cost of HIV care with PrEP	3 369 203	3 419 242	3 467 227
Budget Impact	**148 898**	**114 139**	**79 345**
Budget Impact (%)	**4.6**	**3.5**	**2.3**
Budget impact with 70% PrEP effectiveness			
Total additional cost of HIV care with no PrEP	3 220 305	3 305 103	3 387 882
Total additional cost of HIV care with PrEP	2 861 088	2 903 051	2 943 633
Budget Impact	**(359 217)**	**(402 052)**	**(444 249)**
Budget Impact (%)	**(11.2)**	**(12.2)**	**(13.1)**
Budget impact with 10% reduction in HIV care costs			
Total additional cost of HIV care with no PrEP	2 898 274.50	2 974 592.70	3 049 093.80
Total additional cost of HIV care with PrEP	2 929 061	2 972 302.70	3 013 625
Budget Impact	**30 785.50**	**2 290**	**(35 468.80)**
Budget Impact (%)	**1.1**	**0.1**	**(1.2)**
Budget impact with 10% increase in HIV care costs			
Total additional cost of HIV care with no PrEP	3 542 335.50	3 635 613.30	3 726 670.20
Total additional cost of HIV care with PrEP	3 301 903	3 350 663.30	3 397 235
Budget Impact	**(240 432.50)**	**(284 950)**	**(329 435.20)**
Budget Impact (%)	**(6.8)**	**(7.8)**	**(8.8)**
Budget impact with 10% reduction in PrEP costs			
Total additional cost of HIV care with no PrEP	3 220 305	3 305 103	3 387 882
Total additional cost of HIV care with PrEP	2 990 354.80	3 034 515	3 076 692
Budget Impact	**(229 950.20)**	**(270 588)**	**(311 190)**
Budget Impact (%)	**(7.1)**	**(8.2)**	**(9.2)**
Budget impact with 10% increase in PrEP costs			
Total additional cost of HIV care with no PrEP	3 220 305	3 305 103	3 387 882
Total additional cost of HIV care with PrEP	3 240 609.20	3 288 451	3 334 168
Budget Impact	**20 304.20**	**(16 652)**	**(53 714)**
Budget Impact (%)	**0.6**	**(0.5)**	**(1.6)**
Budget impact with 10% reduction in adherence rate			
Total additional cost of HIV care with no PrEP	3 220 305	3 305 103	3 387 882
Total additional cost of HIV care with PrEP	3 318 728	3 368 094	3 414 733
Budget Impact	**98 423**	**62 991**	**26 851**
Budget Impact (%)	**3.1**	**1.9**	**0.8**
Budget impact with 10% increase in adherence rate			
Total additional cost of HIV care with no PrEP	3 220 305	3 305 103	3 387 882
Total additional cost of HIV care with PrEP	2 912 236	2 954 872	2 996 127
Budget Impact	**(308 069)**	**(350 231)**	**(391 755)**
Budget Impact (%)	**(9.6)**	**(10.6)**	**(11.6)**
Budget impact with 10% reduction in PLHIV			
Total additional cost of HIV care with no PrEP	2 900 630	**2 974 660**	3 049 363
Total additional cost of HIV care with PrEP	2 806 944	**2 845 402**	2 885 005
Budget Impact	**(93 686)**	**(129 258)**	**(164 358)**
Budget Impact (%)	**(3.2)**	**(4.3)**	**(5.4)**
Budget impact with 10% increase in PLHIV			
Total additional cost of HIV care with no PrEP	3 545 364	**3 634 873**	3 727 074
Total additional cost of HIV care with PrEP	3 430 182	**3 477 564**	3 526 091
Budget Impact	**(115 182)**	**(157 309)**	**(200 983)**
Budget Impact (%)	**(3.2)**	**(4.3)**	**(5.4)**
Best case scenario			
Total additional cost of HIV care with no PrEP	3 190 693	3 272 126	3 354 299.30
Total additional cost of HIV care with PrEP	2 374 353.50	2 407 619.70	2 441 310.70
Budget Impact	**(816 339.50)**	**(864 506.30)**	**(912 988.60)**
Budget Impact (%)	**(25.6)**	**(26.4%)**	**(27.2)**
Worst case scenario			
Total additional cost of HIV care with no PrEP	3 190 827.60	3 271 385.70	3 354 366.60
Total additional cost of HIV care with PrEP	3 782 420.30	3 834 944.30	3 888 593.20
Budget Impact	**591 592.70**	**563 558.60**	**534 226.60**
Budget Impact (%)	**18.5**	**17.2**	**15.9**

The time horizon for the study was short. Doing a BIA for three years might have missed future savings that might be realised with the adoption of PrEP. However, despite these limitations, we believe that the results of this study are useful as no study of this kind had been done in Namibia. Moreover, using the MOHSS perspective was relevant since it is the MOHSS that decides on the adoption of PrEP in the public health sector in Namibia.

5. Conclusion

The BIA for Namibia showed that adopting PrEP may save costs from the first year of adoption. Therefore, we recommend that MOHSS adopt PrEP since it may be cost saving. However, it should target the people at high risk since this may be more cost-saving. A bottom-up costing study should be conducted in Namibia to determine exact costs of HIV care and PrEP. If PrEP is adopted, adherence should be reinforced since it directly influences PrEP effectiveness. Adherence rates of more than 70% may be required to

achieve cost savings with PrEP adoption. If PrEP is adopted, a follow-up BIA should be carried out to determine if this novel BIA reflected reality. The BIA should be conducted alongside a CEA since both analyses may complement each other in providing better information to the MOHSS for decision making.

CRediT authorship contribution statement

Conceptualisation: **Enos Moyo and Leela Barham**, Methodology: **Enos Moyo and Leela Barham**, Formal analysis: **Enos Moyo and Malizgani Mhango**, Writing - original draft: Enos Moyo, Writing - review & editing: **Leela Barham, Malizgani Mhango, Godfrey Musuka, Tafadzwa Dzinamarira, Supervision: Leela Barham and Tafadzwa Dzinamarira**, All authors have read and agreed to the published version of the manuscript.

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The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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