Original Article

Cost-Benefit Analysis of a Population-Based Prostate-Specific Antigen Mass Testing for Early Detection of Prostate Cancer in Anambra State, Nigeria: A Health Provider's Perspective

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Abstract

Aims: We conducted a cost-benefit analysis of a population-based prostate-specific antigen (PSA) mass testing for prostate cancer (PCa) from a provider's perspective to give further insights into the programme's sustainability at scale-up. **Materials and Methods:** A cross-sectional study design was adopted. The cost and benefit of the population-based-specific antigen mass testing were estimated using activity-based costing and participants' willingness to pay (WTP), respectively. The study was conducted in a primary health-care facility in Anambra State, Nigeria. A total of 412 asymptomatic males between 40 and 74 years who had not had a PSA screening within the past five years were recruited for the study. A one-month population-based PSA mass screening for PCa was performed at the primary health-care facility. The cost of population-based PSA mass testing was presented as cost/male screened while benefit was measured as the participants' minimum WTP analysis amount. Benefit-cost ratio (BCR) served as the primary outcome, with values higher than one signifying a self-sustainable programme. **Results:** The cost/male screened was USD 13.43 ± 2.26, while the participants' WTP amount of US$3.99 ± 4.49 to calculate the BCR gave a BCR ratio of 0.3. **Conclusion:** The estimated BCR showed that the programme would not be sustainable if funding were based solely on participants' out-of-pocket expenses. Other financing mechanisms, such as donor funds, will be necessary to sustain such public health programmes in Nigeria.

Keywords: Acceptance, Anambra state, cost-benefit analysis, Nigeria, population-based screening, prostate cancer, prostate-specific antigen, willingness to pay

Introduction

Worldwide, prostate cancer (PCa) is the sixth-leading cause of death and the second most common cause of cancer among men.[1,2] Figures from the global database show that there were 1.1 million diagnosed cases of PCa in 2012, with a mortality rate of 307 thousand patients (6.6%).[3] The incidence and prevalence of PCa are on the increase among African men.[4] In African men Nigeria, PCa is the leading cause of death among men; it is usually aggressive and seen at a late stage.[4]

Early detection of PCa can be carried out using prostate-specific antigen (PSA) screening, digital rectal examination (DRE), and trans-rectal ultrasound-guided biopsy. Among these diagnostic techniques, PSA is the most accurate single diagnostic tool.[2,5,6] "PSA testing has also resulted in early-stage PCa diagnosis and a decline in advanced stage and distant metastasis and an

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increased survival rate."[2,7,8] Organised PSA-based mass testing for PCa has offered a systematic, timely diagnosis of aggressive PCa at a very curable stage and with a decreased mortality.[9-11]

Notwithstanding, the recommendation of PSA screening for PCa remains controversial, probably due to concerns about overdiagnoses, over-treatment, and consequent side effects.[2,9,10] There is published evidence on the efficacy of PSA screening in reducing PCa deaths.[11-14] In Nigeria today, PSA-based testing is usually the initial means of screening for PCa accepted by many practitioners.

The out-of-pocket payment as a primary means of health financing in Nigeria has made the uptake of preventive health services, including PCa screening, low. However, considering the enormous resource required for the treatment of late-stage PCa disease, early diagnosis becomes essential. Efforts should be made to explore other models like mass screening as a means of providing the screening to the populace.

Organised mass PSA testing for PCa is still not common in Nigeria.[4,15] The Nigerian male population is regarded as an unscreened group regarding prostate health.[4] Organised mass testing is usually done by nongovernmental organizations (NGOs) periodically based on their funding availability. These testing are currently sporadic in Nigeria because of limited funding and other competing priorities such as HIV, COVID-19, maternal health, etc. For organised periodic testing for PCa to be sustained in Nigeria, there is a need to explore financing options (including out-of-pocket payment by the participants) to fund such programmes or augment funding support received by donor agencies for conducting the organised mass screening.

To aid decisions on possible financing options for such intervention, an economic evaluation of the cost and benefit of such intervention will be necessary.[16-22] This study, therefore, aimed to assess the cost-benefit analysis of population-based mass PSA testing for the early detection of PCa in Nigeria.

Materials and Methods

Description of the prostate-specific antigen mass testing programme

A free pilot population-based mass PSA testing was carried out in primary health care (PHC) facility in Omagba, Onitsha of Anambra state in southeast Nigeria from June to August 2021. Anambra state had an estimated total population of 5,527,809 and a 2,819,182 male population by the end of 2016, based on the 2006 Nigerian census.[23] Omagba in Onitsha town is a highly built-up and densely populated area of the state with an estimated population of over 1 million, with a male-to-female ratio of 5:3.[24] PSA, is a protein produced by normal, as well as malignant, cells of the prostate gland. The PSA test measures the level of PSA in the blood. The blood level of PSA is often elevated in people with PCa and other benign prostate diseases. For this test, a blood sample is sent to a laboratory for analysis. The results are usually reported as nanograms of PSA per milliliter (ng/mL) of blood with a cutoff point of 4 ng/ml.[9]

The town was notified of the one-day free education and awareness workshop on PCa using massive awareness strategies such as radio announcements, face-to-face information, and community morning criers. During the programme, the participants were informed about the one-month PSA testing programme at the community primary health care center.

Eligible participants from the programme attendant register who provided informed consent for the programme were invited for free PSA testing at the PHC using a short message service (SMS). At the PHC, screening was scheduled from 8 am to 12 noon, Mondays through Fridays. The screening programme was carried out in collaboration with an accredited medical laboratory. All the programme staff was trained on the guidelines for data collection, sample collection, and packaging of a blood sample for delivery to the participating medical laboratory. Before the PSA testing, the biodata forms and research questionnaires used in assessing the willingness to pay (WTP) were administered by the public health nurse and research assistants. A 4 ml blood sample volume was collected by venipuncture from each participant, packaged, and sent to the medical facility using the laboratory rider. The blood samples were centrifuged and analysed for Total PSA (TPSA) value at the laboratory using the COBAS E411 electrochemiluminescence procedure. The remaining sera were stored in the solar-powered medical refrigerator for reference. All the participants were notified about their results through an SMS. Participants with a mark above the cutoff point of 4 ng/ml were linked to the urologist for further urologic evaluations. These patients had an ultrasound-guided prostate biopsy.

Study design

The study used a cross-sectional study design approach using a total population sampling method whereby all eligible males who attended the screening programme were included. The cost and benefit of the population-based-specific antigen mass testing were estimated using activity-based costing and participants' WTP, respectively. The PHC was conveniently selected because of the dense population it serves and its proximity to the researcher. The PHC facility is a 3-bedroom apartment with three beds, two community nurses, three midwives, two public health workers, a visiting doctor, and other health-care workers who are well-trained in rendering health services.

The inclusion criteria for the screening were asymptomatic males between 40 and 74 years who resided in the study area and had not had a PSA screening within the past five years. Exclusion criteria include the presence of hematuria and men previously diagnosed with PCa and other prostate diseases. All eligible men who gave consent for the study were included.

Cost analysis

Provider perspective was adopted for the study. Only the economic cost of the programme was assessed. This depicts

the actual value, that is, the financial cost and opportunity cost of the item.[25] The cost items were divided into two major categories: capital and recurrent expenditures.

The collection of the cost data occurred within one month in July 2021 in the primary health facility and one week in the participating laboratory. The base year for cost data collection was 2021. All the resources used for providing the PSA testing services were identified, enumerated, and valued. Cost data were obtained by direct observation and interviews of the study and site staff. The cost data only included costs directly related to the screening procedure.

An ingredient-based costing approach was used. 'This involved multiplying the number of resources consumed by their unit prices to get the total cost for the screening and then dividing the total cost by the total number screened to obtain the cost per male screened'.[20] A top-down calculation was used to allocate capital resources based on the proportion of their use by the programme. Capital cost comprised of the cost of equipment and one-off startup cost. The capital costs were estimated and annuitized using the current market prices of the items alongside their useful life years at a 3% annuitization factor.[26] A five-year useful life year was assumed for all equipment. The building cost was estimated by considering the cost of renting a similar space in the area.[27] The personnel time in the screening facility and the laboratory was obtained by estimating the average time spent on PSA testing of 10 participants. Gross salaries from Nigerian salaries for medical workers from the federal ministry of health, including the basic wages, call duty allowance, hazard allowance, and housing allowance, were used to calculate the personnel cost. The cost per hour of staff working time was estimated by dividing the annual salary by total working hours in a year, that is, the eight hours per day for five working days per week, i.e., 40 h/week, and excluding 30 days annual leave and 11 days public holidays in 2021.[23,28] The mean time spent by the staff for each screening was multiplied by the cost per minute of each staff working time. The value-added tax was excluded from the cost as medical programmes and services are nontaxable in Nigeria.[29] All cost measurements were done using their equivalent market prices in 2021 local Nigeria currency units (Naira) and presented in United States Dollars (US$) using the 2021exchange rate (409.16 Naira = 1USD), then adjusted to 2022 dollar equivalent using the consumer price index calculator of the US Bureau of labour statistics.[25,26]

The data were collected and coded into Microsoft excel version 2016 and then exported into SPSS version 20.0 (Chicago, IL, USA). Descriptive statistics using frequencies were used to describe the questionnaire data. The cost data were analysed for an economic cost, and the results were presented in US dollars. The various data used to arrive at the cost calculations are shown in Table 1.

Table 1: Data sources used for cost analysis

Parameter	Data	Data source
Annualization factor	At 3%	Levin and McEwan annualization factor table
Useful life years for equipment	5 years	Published (20)
Exchange rate	409.16=1 USD	CBN exchange rate
Staff salaries	Staff gross earnings	Finance/Ministry of Health
Cost per test for TPSA screening	US$8.3	Quotes from Roche Pharmaceutical cost per test for TPSA using COBAS E411 Chemistry Analyser

*1 USD=409.16 Nigerian Naira (2021). (Central bank of Nigeria's exchange rate 2021, https://www.cbn.gov.ng/). PSA: Prostate-specific antigen, TPSA: Total PSA

Willingness to pay analysis

The study employed a contingent valuation method to assess the participant's WTP analysis for PSA testing. The payment card elicitation format was used to assess the perceived benefit of the programme among the study participants. The participants were given a self-administered, validated questionnaire which was used to assess participants' socio-demographic characteristics, knowledge of PCa and PSA, acceptance for the PSA routine testing, preference for screening sites, and WTP for the PSA test. The payment card allowed the participants to choose from a scale with a range of prices and their maximum WTP for the screening after a brief scenario description of the intervention. "Acceptance of the screening was assessed based on the response to the question," What if the population-based mass PSA screening is not free and you are supposed to pay out-of-pocket to get screened? Will you be willing to pay for the screening? The respondents that gave a positive answer and a positive WTP value were classified as acceptors of the programme, while those that gave a negative response or zero WTP values were regarded as rejecters. Respondents that gave positive responses were instructed with a follow-up question to indicate on the payment card with a tick mark symbol the maximum amount they were willing to pay. The presented prices on the scale ranged from 0 Naira to more than 12500 Naira (equivalent to US$0– US$30.6) 2021 CBN exchange rate. The payment card contained an open-ended question where the respondents were required to state their WTP amount if their WTP amount was not represented on the scale. The maximum amount they were willing to pay was considered their perceived monetary benefit of the intervention. This is in line with the welfare economics theory, which states that the benefits individuals place on intervention is defined by their maximum WTP for the intervention.[22] The different payment card scales with a varied range of prices were randomly given to the respondents to avoid range bias. The prices on the payment card were written in Nigerian currency, but the presented results are expressed in US dollars (NGN 409.16 ≈ US$ 1.00).

Benefit-cost analysis

The cost-benefit analysis of the population-based mass PSA testing for PCa based on the provider's perspective was performed by evaluating the benefit-cost ratio (BCR). This involves dividing the mean benefit by the average cost. The benefit was measured as average WTP for the screening.

The cost included the total expenses for the PSA mass PCa screening incurred during the screening programme. A value >1.0 (BCR > 1) shows that the respondents' perceived benefit exceeds the cost, and the project should be allowed to proceed. BCR values <1.0 (BCR < 1) in economic terms mean that cost surpasses the benefit, thus, if decisions are based exclusively on the BCR principle, the project should not be implemented. Finally, if the BCR value is equal to 1.0 (BCR = 1), the project should be allowed to continue with equal probability.[30]

Sensitivity analysis

For the cost estimates, a sensitivity analysis was performed to examine the variation of the estimated cost based on parameter uncertainty. A one-way sensitivity analysis was done by varying the following parameters: the rate on overheads was increased to 25% and 75% to mimic equivalent overheads cost in higher health-care facilities. The personnel cost also varied to as high as 25% and 75% assuming higher health-care facilities with higher personnel costs. The discount rate was varied at 5% and 10% to depict all possible variations in capital cost. The Laboratory cost for TPSA was increased to 50% to represent the conventional cost of TPSA obtained in most public health facilities. In the event of a mass screening programme, there is the possibility of getting the screening reagents at a discounted rate, so a 10% reduction in TPSA was considered. Since TPSA cost was a significant driver, it was excluded at specific points in the sensitivity analysis to assess the impact.

As a result of parameter uncertainty, estimating the cost benefit with the average parameter estimates will not be ideal, so a probabilistic sensitivity analysis was conducted to test the robustness of our findings in the face of these uncertainties. The probabilistic sensitivity analysis permits concurrent analysis of possible cost and benefit estimate variations in real-life scenarios. Monte Carlo simulation was conducted using lognormal distribution for the cost and benefit estimates. For the simulation, 10,000 iterations were made that respectively generated different costs and benefits. The simulated data's mean (95% confidence interval) was used to test the change in BCR. The Monte Carlo simulation was conducted using Excel 2016.

Results

Sociodemographic characteristics of the study participants

A total of 585 males attended the programme. Out of these, 500 participants gave consent for the screening. Hence, 500 invitations were sent using SMS after the one-day awareness programme, out of which 412 participants attended the screening, and this gave a response rate of 82.4%. The mean age of the participants was 56.34 years (standard deviation ± 12.89 years). Most of the participants were married, with only a few having no form of formal education. Most of the study participants reported having less than 122US$ as their monthly income. Fifty percent of the participants knew about PSA, and the Internet was the primary source of information about PSA. Details of the sociodemographic characteristics of study participants are shown in Table 2.

Clinical outcomes of the intervention

The clinical outcomes of the intervention are shown in Tables 3-5. The average PSA value among the study participant

Table 2: Demographic characteristics

Variables	Mean, frequency (%)
Age	
Mean	56.34
Median	55
SD	12.89
Marital status	
Married status	381 (92.5)
Single	31 (7.5)
Educational status	
No education	10 (2.4)
Primary education	149 (36.2)
Secondary education	149 (36.2)
Tertiary education	104 (25.2)
Monthly income	
<50,000 NGN (122 US$)	267 (64.8)
50,000–100,000 NGN (122–244 US$)	109 (26.5)
Above 100,000 NGN (244 US$)	36 (8.7)
Knowledge of PSA screening	217 (52.7)
No knowledge of PSA screening	195 (47.3)
Source of information PSA screening	
Mass media	47 (11.4)
Health professionals	67 (16.3)
Internet	155 (37.6)
Family and friends	97 (23.5)
Others	46 (11.2)

1 US$=409.16 Nigerian Naira (2021). (Central bank of Nigeria's exchange rate 2021, https://www.cbn.gov.ng/). PSA: Prostate-specific antigen, SD: Standard deviation

Table 3: Distribution of the prostate-specific antigen values among the study participants

Statistics *n*	PSA (ng/ml)	PSA range (ng/ml)	Frequency (%)
Mean	8.1489	>4	111 (26.9)
Median	1.2550	0-4	301 (73.1)
Mode		100.00	
SD		22.47511	
Age group	**PSA group**		
	>4 (%)	**0-4 (%)**	**Total (%)**
30-39	0	18 (6.0)	18 (4.4)
40-49	7 (6.3)	121 (40.2)	128 (31.1)
50-59	22 (19.8)	82 (27.2)	104 (25.2)
60-69	37 (33.3)	51 (16.9)	88 (21.4)
70-79	30 (27.0)	21 (7.0)	51 (12.4)
80-89	13 (11.7)	8 (2.7)	21 (5.1)
>90	2 (1.8)	0	2 (0.5)
Total	111 (100.0)	301 (100.0)	412 (100.0)

*χ^2=93.39, *P*=0.0001, Pearson correlation=0.348. PSA: Prostate-specific antigen, SD: Standard deviation

was 8.14 ng/ml. Most of the study participants, 301 (73.1%), had normal PSA values between 0 and 4 ng/ml. About 26.9 percent of the participant had PSA values beyond the normal value of 4ng/ml. Participants between the ages of 60 and 69 had the highest (33%) PSA values. Most participants (59.8%) were diagnosed with benign prostate hyperplasia, while only 13.8% were diagnosed with PCa. Most patients (66.8%) were placed on androgen deprivation therapy.

The result also showed a positive and moderate relationship ($p = 0.0001$) between age and PSA, i. e., PSA increases with age. Likewise, the correlation between the diagnosis of PCa and PSA level; as PSA level increases, the chances of diagnosis of PCa increases ($P = 0.0001$).

Benefit estimation

The overall acceptance rate of the programme by the study participants was 90.6% (374). The stated WTP amount for the mass PSA testing for PCa was US$ 3.99 ± 4.49 [Table 6].

The economic cost of prostate-specific antigen mass testing for prostate cancer

Table 7 shows the economic cost of the screening programme. The total economic cost of the programme was estimated at US$55,532.14, which comprises 24.34% capital costs and 75.66% recurrent items. Based on the number of males screened during the programme, the estimated cost per screened male was US$13.43 ± 2.26.

The primary cost item was the laboratory cost for TPSA screening at 58.1% of the total economic cost of the screening, followed by awareness and education event estimated at 13.88% of the total economic and medical supplies and consumable cost estimated at 10.2% of the total cost of the screening.

Cost-benefit analysis

Table 8 shows the base case analysis results for the cost-benefit analysis. For the base case, using the estimated WTP amount of US$3.99 and cost per test of 13.4 ± 2.26 USD to calculate the BCR gave a BCR ratio of 0.3 and shows no return on investment.

Sensitivity analysis

Table 9 shows the result of the one-way sensitivity analysis. Excluding the cost for laboratory costs for TPSA screening and capital costs yielded a 58% and 24% reduction in the total cost of the screening and BCR values of 1.21 and 0.67, respectively. Increasing the laboratory cost for TPSA by 50% and adjusting the personnel cost by 75% increase produced a 5.8 and 3.5% increase in the total cost of the screening and BCR values of 0.39 and 0.48, respectively. Varying the discount rate and overhead cost did not significantly change the total cost of the screening and the BCR.

The result of the probabilistic sensitivity analysis from 10,000 iterations gave mean benefit and cost values of 4.0 ± 4.5 USD and 13.4 ± 2.3 USD, respectively. This translated to an average BCR of 0.3 and yielded no positive return on investment.

Table 4: Summary of the prostate cancer diagnosis

Diagnosis	Histologic diagnosis (%)
Benign prostatic hypertrophy	52 (59.8)
Chronic prostatitis	19 (21.8)
Prostate cancer	12 (13.8)
High grade prostatic intraepithelial neoplasia	4 (4.6)
N	87 (100)
Relationship between PSA values and prostate cancer diagnosis	
PSA	**Positive prostate cancer diagnosis**
Pearson correlation	0.532
P	0.0001
N	87

PSA: Prostate-specific antigen, *P*: *P*-value, *N*-Total sample

Table 5: Summary of the treatment

Treatment received	Frequency (%)
Androgen deprivation	8 (66.67)
Radical prostatectomy	3 (25)
Radiation	1 (8.33)
Total	12 (100)

Table 6: The acceptance and willingness to pay amount by the study participants

Statistics	WTP per screening (US$) (*n*=412)
Mean±SD	3.99±4.49
Median	2.44
Mode	2.44
Percentiles	
20	1.22
90	9.7

*1 US$=409.16 Nigerian Naira (2021). (Central bank of Nigeria's exchange rate 2021, https://www.cbn.gov.ng/). WTP: Willingness to pay, SD: Standard deviation

Discussion

Screening means testing for disease in healthy individuals to identify disease early stage and potentially cure the patient. Screening carries a risk of stage migration and overdiagnosis, but this usually occurs over time after the disease burden has been reduced significantly by screening.[31]

PCa is one disease that screening of the at-risk population has led to a reduction in mortality.[31] It is well known that PCa is common and more aggressive in black men.[32,33] Randomised trials in developed countries have shown that to prevent one PCa death, you have to screen 1410 men and treat an additional 48 men.[34] We strongly believe this fact is not applicable in Nigeria because of the high incidence of PCa and mortality.[34]

PSA is produced by the epithelial cells of the prostate gland. The higher the value of PSA, the higher the likelihood of malignancy. Normal PSA value is from 0 to 4 ng/ml; however, there is no PSA value at which PCa can be ruled out. This

Table 7: The economic cost of population-based prostate-specific antigen mass screening for prostate cancer (2021 prices)

Item	Type of resource	Total economic cost (US$)	Unit cost (USD)	Cost profile (%)
Capital items	Equipment cost			
	8-bucket centrifuge Human 3k	3.91	0.01	0.07
	31L Zhongke 2 to 8 degrees Medical, solar Refrigerator	8.72	0.02	0.16
	Nonrecurrent startup cost			
	Social mobilization	496.93	1.21	8.98
	Awareness and education event	767.63	1.86	13.88
	Training of facility staff	69.40	0.17	1.25
	Subtotal	1346.59	3.27	24.34
Recurrent items	Building cost (rental value)	22.00	0.05	0.398
	Utilities	43.99	0.11	0.8
	Personnel cost	305.76	0.74	5.53
	Medical supplies and consumables	566.21	1.37	10.24
	Transportation of samples	34.00	0.08	0.62
	Laboratory cost (for TPSA)	3213.60	7.80	58.09
	Subtotal	4185.55	10.16	75.66
	Total cost	5532.14	13.43	100.00
	Cost per screening	13.43		

*1 US$=409.16 Nigerian Naira (2021). (Central bank of Nigeria's exchange rate 2021, https://www.cbn.gov.ng/). PSA: Prostate-specific antigen, TPSA: Total PSA

Table 8: Net benefit result; base-case analysis (2021 US dollars)

Parameters	Average cost (US$)	Mean benefit (mean WTP) (US$)	Net benefit (BCR)
Base-case	13.4	3.99	0.3

1 US$=409.16 Nigerian Naira. (Central bank of Nigeria's exchange rate 2021, https://www.cbn.gov.ng/). *BCR: Benefit-cost radio, WTP: Willingness-to-pay

study's mean PSA was 8.1489 ng/ml, with a range of 0.01 to 153 ng/ml. Other studies on PCa have higher values.[35,36] The variations in these PSA values are due to the study participants' nature; this current study is a screening study, while the others are on PCa management.

In this study, 26.9% of respondents had a PSA value above 4ng/ml. This group of patients was further analysed, and a prostate biopsy was carried out. The study noticed a statistically significant moderate positive correlation between PSA and age. As age increases, the chance of elevated PSA and PCa increases. This shows how vital screening will be for this population of aging men.

Although 111 men had PSA above 4 ng/ml, 87 men were fit and consented to a biopsy. Twelve (13.8%) men were diagnosed with PCa. The most common histological diagnosis was benign prostatic hypertrophy, diagnosed in 59.8% of men. A recent hospital-based study conducted in Port Harcourt, Southern Nigeria, found that over 50% of patients biopsied had PCa.[35] However, this study was conducted in men suspected to have PCa, hence the higher percentage of men with PCa.

In contrast, our study was screening based. A screening study conducted in Lagos, Nigeria, had a similar result as ours, with 43 out of 438 (9.81%) men biopsied having histologically confirmed PCa.[37] This study also noticed a statistically significant correlation between PSA and a histological diagnosis of PCa. The higher the PSA, the higher the chance of getting a diagnosis of PCa.

Three patients had a diagnosis of early PCa, as shown in Table 4, had radical prostatectomy, and a third had radiation therapy. These patients have been potentially cured of their PCa due to this screening programme. Nine other patients were placed on androgen deprivation therapy; 6 had orchidectomy because they could not afford medical castration, while 3 had medical castration. Three patients have been potentially cured out of 412 subjects, and an additional nine men have some form of succor due to this screening programme. This shows that screening is essential in at-risk populations such as black men. The four patients with high-grade PIN are also being followed up. In Nigeria, there is always a temptation to adopt whatever is obtainable in the Western world without considering its impact on our own country. PCa is the most common cause of cancer death in men. Screening is one step that can help reduce the morbidity and mortality associated with PCa.

Based on the provider perspective, the study also assessed the cost and benefit of the population-based PSA mass testing for PCa among men in a primary healthcare facility in Anambra state. The study's major aim was to determine whether it was cost-beneficial to carry out routine mass PSA testing for PCa using a lower health-care facility that is usually more accessible to the populace. The study also examined the economic outcome of the intervention. Data from the study showed that the cost per test was US$13.43; putting this side by side with the stated WTP of the study participants of US$3.99 for the screening to run the complete cost-benefit analysis produced no significant return on investment.

Table 9: Result of the sensitivity analysis (2021 US dollars)

One-way sensitivity analysis	Mean cost US$	Mean benefit (WTP) US$	Net benefit (BCR)
Base case	13.4	6.9	0.5
↑ 50% TPSA cost	12.6		0.4
↓ 10% TPSA cost	17.3		0.5
↑ 25% overhead cost	13.5		0.5
↑ 75% overhead cost	13.5		0.5
↑ 25% personnel cost	13.6		0.5
↑ 75% personnel cost	13.9		0.5
5% discount	13.4		0.5
10% discount	13.4		0.5
TPSA cost excluded	5.6		1.2
Capital cost excluded	10.2		0.7
	Mean cost	**Mean benefit**	**Net benefit**
Probabilistic sensitivity analysis (95% CL LL–UL), the mean	13.4±2.3 (15.51–15.62)	4.0±4.5 (4.55-4.65)	0.3 (0.293-0.298)

↑=increased,↓=decreased, 1 US$=409.16 Nigerian Naira (2021). (Central bank of Nigeria's exchange rate 2021, https://www.cbn.gov.ng/). *BCR: Benefit-cost ratio, WTP: Willingness-to-pay, LL: Lower limit, UL: Upper limit, CL: Confidence limit

Most of the study participants accepted the mass PSA testing for PCa. The primary cost driver was the cost per test for TPSA. The sensitivity analysis showed a substantial reduction in the cost of screening and a positive return on investment when the cost of TPSA was excluded at some points in the analysis.

The result of the BCR showed a poor return on investment by the programme, probably due to the low WTP value attached to the PSA testing. In BCR analysis, a value less than one depicts a low return on investment.[22,30,38] Many reasons could have prompted the obtained low WTP values from the participants. Currently, the most typical means of health financing in Nigeria is out-of-pocket payment, as few people (mainly public servants) are covered by health insurance.[39,40] Due to the out-of-pocket payment, low priority is given to preventive health care services due to competing needs. Second, there is no routine national screening programme currently available in the country, so attaching values to a non-existing health programme based on the scenario description used in the contingent valuation study might be difficult for the participants. There is a need for more awareness and orientation of the populace on the benefits of embracing preventive health services. The high acceptance rate for the screening could also mean that the stated low WTP amount may have resulted from financial constraints. This is an excellent basis for possible public health investment opportunities for any organisation that wants to fund mass screening to reduce the burden of PCa in Nigeria. As such, an intervention will have a reasonable acceptance rate by the users.

The estimated cost of PSA screening, even though it falls below the realized benefit (WTP), is still lower than the cost of routine PSA screening in most of the public and private secondary health-care facilities in the state, which is estimated at between US$17 and 24 based on expert opinion. The lower cost may probably result from the primary health-care facility used for the study. The primary health-care facility represents lower-level health facilities with a more affordable workforce. It is expected that services in PHC should be less expensive. Higher hospital-based services are expected to cost more than primary health-care facilities.[20] This is mainly due to higher capital and recurrent costs, especially personal costs.[25] Other studies carried out in PHC have also recorded a lower cost of care.[20,41]

Few studies have tried to quantify the cost of PSA screening for PCa.[18,38,39] A study in Canada that evaluated the actual cost of PSA screening based on provider perspective reported PSA testing costs to be about USD 11.00.[19] The study concluded that PSA screening was comparatively modest and accounted for only 1.4% of all cancer costs. Two studies in the USA and Kazakhstan evaluated the unit cost of PSA screening in a public health facility to be US$10 and 7.99 USD in 2013, respectively.[3,42] The estimated WTP amount among the study participants was comparable to an initial estimated WTP value of US$ 6.85 for mass PSA testing among men in Anambra state from our previous study in 2019 (Accepted manuscript; Umeh *et al*., African health science journal).

The estimated cost of screening appears to be high for an out-of-pocket payment for an average Nigerian if we consider that 63% of Nigerians live below the international poverty line of $2.15 per person per day.[43] Moreover, since the stated WTP could not offset the estimated cost of the screening, other financing mechanisms can be sought to make this service available to the populace. Co-payment options like subsidies and pay-for-service can be a means of making routine screening affordable to the public. The government could consider affordable health-care plans, especially for the aging population in whom out-of-pocket payment for healthcare needs is usually tricky. They could also consider providing such service free of charge, especially to under-serviced areas like rural locations. NGOs should be encouraged to invest more in such preventive health-care services. Even multinational companies can be educated on the need for such services to be part of their cooperate social responsibility.

In general, as stated earlier, mass PSA testing for PCa has faced many controversies resulting from conflicting reports on its

efficacy as a screening strategy and its perceived consequences, like over-treatment, as reported by some studies.[2,9.10] This affects health policy decisions and voting for its inclusion in funded health services. PSA and DRE usually run concurrently as screening strategies in the developed world. Still, in Nigeria, PSA testing remains the standard practice for early detection of PCa among medical practitioners based on expert opinion. Until more data are made available to discredit the potency and efficacy of PSA testing as a PCa screening method, PSA testing will still be considered a gold standard for detecting PCa in Nigeria. Second, in Nigeria today, opportunistic hospital-based PSA testing has not yielded the required result, as Nigerian men are usually present at the health-care facility at a late stage of PCa.[4] Strategies such as population-based mass PSA testing to make this service popular, more accessible, and affordable for users should be prioritised.

The sensitivity analysis to test the robustness of the estimated cost for the screening revealed a significant decrease in the programme's total cost when the Laboratory cost for TPSA was excluded. There was no significant change when the other uncertain parameters were varied. This implies that the laboratory cost for TPSA is a primary cost driver in planning an organised population-based PSA mass screening for PCa. Strategies to reduce its costs, such as the bulk purchase of screening reagents at a discounted rate, will be the first consideration in planning a mass PSA screening programme.

We acknowledge the limitations of this research. The study was a cross-sectional study involving a small population sample; conventionally, the societal perspective is expected in any CBA.[22,44,45] This study adopted a health-care provider/programme perspective. Other relevant CBA considerations will be required to explore a broader cost and benefit analysis of such a programme. A consideration of society's valuation of the health-care cost could have been included on the cost side. Furthermore, for the welfare estimate, the general population's WTP should have been included, not only males within the screening age, to capture the societal WTP values. To account for all possible externalities, a combined sample of males within the screening age and general population benefit might also be more relevant from a broader perspective.[44,45] Another limitation of the contingent valuation experiment is the sample size; the sample used for the WTP estimate was obtained only from the study participants, so it may not be the complete representation of the WTP of every male in Nigeria. Due to the unavailability of data, other means of benefit estimation, like the value of statistical life, could not be explored. Notwithstanding, to the best of our knowledge, this is the first study to report the descriptive cost and cost-benefit analysis of a population-based PSA mass screening for PCa in Nigeria.

Conclusion

The estimated BCR for the population-based mass PSA testing based on the provider perspective yielded no return on investment. The estimated cost of the intervention of US$13.43 is still less than that of conventional PSA screening in most public hospitals in Nigeria, rated at about US$17. This shows that a population-based mass screening could still be a viable strategy for the early detection of PCa in Nigeria. Alternative financing options like NGO funding, co-payment, and subsidies could be sort to make this programme sustainable and affordable to the populace.

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Conflicts of interest

There are no conflicts of interest.

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