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Revolutionizing Prostate Cancer Care: Unravelling the Effects of Varied Surveillance Intensities on Treatment Quality and Patient Well-Being

Anika Rastogi

Abstract: To validate three different Active Surveillance Care Pathways for men with prostate cancer, Low-Intensity, Intermediate-Intensity, and High-Intensity schedules were evaluated. Three factors related to the appropriateness and quality of care were considered: patient adherence to the schedule, negative biopsy incidence, and time to detection of significant cancer. The intermediate-intensity schedule had the best adherence as 40.9% adhered to their schedule at the confirmatory biopsy and 15.9% adhered to the 36-month surveillance biopsy, showing that it was the least burdensome. In terms of negative biopsy rate, the Low-Frequency and High-Frequency Schedules were shown to be most effective in their patient populations. Finally, the High-Frequency Schedule had the earliest time to detection of significant cancer (n= 691 days) showing the best clinical outcomes. Ultimately, further investigation is needed to determine how to increase adherence to the biopsy schedules that lead to the best clinical outcomes.

Keywords: prostate care, prostate biopsy, biopsy schedule

Introduction

Prostate cancer (PCa) is one of the most commonly diagnosed male cancers; approximately one in six men will develop prostate cancer during their lifetime (Urology, 2021). It is the fifth leading cause of cancer death in men. In 2020, there were approximately 375,000 deaths from PCa (Leslie Stephen, 2023), and the predicted incidence of PCa is expected to increase yearly through 2025 (Kelly, Anderson, Rosenberg, & Cook, 2018). Although PCa remains one of the top causes of cancer mortality in the United States, most diagnoses are of low-risk disease. These patients are defined as those with a Gleason Score of ≤6 (3+3), Prostate Specific Antigen (PSA) < 10, and Clinical State T1-T2. For patients diagnosed with low-risk prostate cancer, one management option is active surveillance (AS), defined as monitoring the tumor(s) through imaging and biopsy assessments to hopefully minimize invasive procedures such as radical prostatectomy and pelvic radiation. In recent years, use of AS as a management tool has increased for patients with low-risk prostate cancer, as it avoids the quality of life (QoL) side effects associated with surgical and radiation treatment options. However, AS does have its own limitations. AS protocols require repeat imaging and follow-up biopsies to identify tumor progression. These biopsies can be very burdensome to patients as they are uncomfortable, expensive, and associated with multiple side effects such as bleeding

and infection, which may be barriers to patient adherence to their schedules (Cooperberg et al., 2020). This ultimately leads to a need to study different AS regimens to ensure that the burden on patients is minimized and adherence, appropriateness, and quality care can be maximized.

Literature Review

Search Strategies

The search for literature and sources was carried out primarily through PubMed and JAMA network. Keywords used while researching were: biopsy schedules, frequency, adherence, complications, and quality of care.

The Burden of Prostate Biopsies

Since the introduction of the widely used transrectal prostate biopsy, infection has been a major concern for urologists. Other major complications for prostate biopsies include urosepsis, rectal bleeding requiring intervention, acute urinary retention, hematuria necessitating transfusion, Fournier's gangrene, and myocardial infarction (Hogan et al., 2021). Minor complications for prostate biopsies include hematuria, hematospermia, rectal bleeding, mild to moderate vasovagal episodes, and genitourinary tract infections. These complications and procedure-related infection rates were reduced with the introduction of the transperineal biopsy approach. Even so, when evaluating the infections and complications rate infections and complications in 2049 patients, Dr. Ozan Efesoy and colleagues found that complications occur in around 21.6% of patients (Efesoy et al., 2013). With this risk of complications, biopsies can be burdensome and patients may not want to adhere to their schedules.

In addition to these complication rates for single biopsies, a 16-year study by Dr. Stacy Loeb and colleagues evaluated Medicare-linked data to determine whether repeat biopsies were associated with a greater risk of hospitalization and complications. She found that the 30-day hospitalization risk was significantly higher among men undergoing multiple repeat biopsies than in the control group of men who only underwent diagnostic biopsies. More specifically, every additional biopsy was associated with a 1.7-fold increase in overall hospitalizations (Loeb et al., 2013). This means that patients are at an increased risk for complications and hospitalization with each additional biopsy. Many patients undergo an average of three biopsies every year, with some patients undergoing as many as six biopsies yearly. The frequent biopsy schedules of such AS regimens can potentially contribute to patients experiencing increased complications, therefore Loeb suggests a need to find the "sweet spot" for the frequency of biopsy schedules that maximize the benefits and reduce unnecessary biopsies to decrease the burden on patients.

In addition to Loeb's study which presents the need to weigh the risks and benefits of frequent, repeat biopsies, Dr. Jane Lange conducted a study evaluating data from five hospitals across America and Canada to look at prostate cancer mortality and metastasis

TERMS AND DEFINITIONS

Gleason Score	Abnormality of prostate cancer and how likely it is to advance and spread
Prostate Specific Antigen (PSA)	A protein made by the prostate gland and found in the blood. It is higher in men with prostate cancer
Clinical State	Stage of the tumor
Active Surveillance	Monitoring of the tumor through imaging and biopsy assessments
Low-risk Prostate Cancer	Prostate Cancer that grows slowly and is unlikely to cause symptoms.

under different biopsy frequencies in North American surveillance cohorts. Like Loeb, Lange found that the more intensive AS schedules have decreased benefits and increased risks and complications. She found that increased frequency biopsy schedules are better than no biopsies at all, but that there is no significant difference between the performance and outcomes of biopsies every 2-5 years and biennial biopsies (Lange et al., 2020). This means that the mean number of biopsies can be reduced without affecting the performance and outcome of the biopsies while only increasing the 20-year risk of metastasis by 0.1%-0.5% and death by 0.2%-0.6%. Given that biopsies are very burdensome and always carry the risk of serious complications, both of these studies suggest that annual biopsies may be unnecessary when there is no change in the disease state of these patients. Although this is the case, it is also important to note, from the results of both studies, that an increased time between biopsies increases the risk of missing a change in cancer, leading to late detection of increased growth/spread of cancer. Therefore, it is necessary to find the ideal biopsy schedule for patients. These schedules need to be frequent enough to find changes in prostate cancer while reducing the number of unnecessary biopsies, as shown in the studies by Loeb and Lange.

Despite the qualms that some may present at the idea of late detection, researchers emphasize that the burden on patients is most important to remember when determining whether it is ethical and feasible to reduce the number of biopsies performed. They also claim that there are increased risks with an increased number of biopsies and are doing further research to determine if there is a way to reduce the burden and risks while also maximizing the outcomes of the biopsies.

Patient Adherence to Biopsy Schedules

Since frequent biopsies are often associated with many complications and risks, patients may find it difficult to adhere to their biopsy schedules. Oftentimes, physicians must take into account several factors such as PSA level, Gleason Score, and MRI results to determine how often patients need to have biopsies. If patients have elevated PSA, this can be a sign of prostate cancer and warrants a more frequent biopsy schedule, but these schedules are often difficult to adhere to and may cause non-compliance or even dropout from AS to convert to other treatments. There is a growing literature that discusses the reasons and rates of noncompliance with AS schedules in men and how physicians can help achieve greater compliance so that patients receive the best care.

Recent studies found that up to one-third of men on AS convert to a different treatment option such as radiation, chemotherapy, and hormone therapy within five years even though there may be no clinical need to convert to more intensive treatment (Beckmann, Cahill, 2021). Furthermore, in a longitudinal study analyzing the data from Prostate Cancer Research International: Active Surveillance, Roobol found that adherence to biopsy schedules has decreased from 92% to 66% within seven years of annual biopsy schedules and that more than half of the men who opted for AS switched to more invasive treatment without any clear indication (Roobol, 2021). To address this, Dr. Kerri Beckmann conducted interviews with patients who dropped out of AS to undergo more invasive treatment to understand the reasons for nonadherence. The most common reasons for dropout were: patient experience at diagnosis, extent of supportive care and information, involvement in shared decision-making, and support from partner or peers (Beckmann, Cahill, 2021). This means that if patients did not have good experiences in the clinic or felt that they did not have the proper support, these factors could adversely affect the patient's adherence to their schedule. To combat this, Dr. Cahill, a colleague of Dr. Beckmann, suggests that effective communication skills aimed at building trust between the patient and physician allow both the clinician and patient to be part of a shared decision-making process to increase long-term adherence.

Adherence to biopsy schedules is crucial as noncompliance can lead to missed detection of cancer and can negatively impact prostate cancer-specific outcomes. When patients do not comply with their biopsy schedules, the quality of healthcare outcomes can decrease and can lead to disease progression. Decreased adherence can also lead to significant complications so patients must make sure that they are complying with their biopsy schedules (Li et al., 2000). When patients have very frequent schedules the compliance rates have been shown to decrease; to find out the impact of this, researchers in the De-

partment of Radiation Oncology at the University of Toronto, Ontario, Canada performed a retrospective analysis on a cohort of 1275 patients. They found that patient non-compliance with the confirmatory biopsy led to higher rates of recurrence. Additionally, patients seemed to comply less over time. This means that, for example, in a biopsy schedule requiring biopsies at years 1,4, and 7, the rates of compliance were 65%, 49%, and 44%. Within this cohort of patients, metastasis was more likely to occur in non-compliant patients. Additionally, rates of overall survival after treatment were lower in patients who were non-compliant with the confirmatory biopsy (Detsky et al., 2020). This means that patients must comply with their biopsy schedules as it increases early detection as well as survival rates. Since patients with more frequent biopsy schedules have higher noncompliance rates, researchers may suggest the implementation of personalized biopsy schedules to reduce unnecessary biopsies in an attempt to increase adherence.

Individualized Biopsy Schedules

Since biopsies are very burdensome and patients may find it difficult to adhere to biopsy schedules, some researchers and urologists have created individual biopsy schedules based on individual risk factors. However, no current consensus exists regarding the optimal frequency of surveillance assessments. In fact, given that prostate cancer has a highly variable biology and natural history even in those with low-risk prostate cancer, a one-size-fits-all approach does not make much biological or clinical sense. Therefore, clinicians have chosen to tailor surveillance intensity based on tumor characteristics and patient factors, such as comorbidity and anxiety (Cooperberg et al., 2020). With the tailoring of these biopsy schedules, clinicians hope to increase adherence to schedules and reduce unnecessary biopsies that may lead to increased risk of complication.

In additional research by Lange, tailored schedules reduced the mean number of biopsies by 0.6-2.5 biopsies and only increased the 20-year risk of metastasis by 0.1%-0.5% and the risk of death by 0.2%-0.6%, both of which are not significant when compared to the number of biopsies that can be reduced (Lange et al., 2020). This means that tailoring the intensity of biopsy schedules can decrease the number of biopsies without increasing the risk or sacrificing the benefit of more biopsies. Even though this may be the case, Dr. Kimberly Roehl, presented a study evaluating the prostate biopsy results in men who had an elevated PSA or suspicious rectal examination results. These men also had negative initial biopsies which meant that the biopsy showed no cancer in the prostate. She found that nearly a quarter of the PCas detected in this study were missed by the initial biopsy and of all the PCas detected, 77% were detected with 1, 91% with 2, 97% with 3, and 99% with 4 biopsy procedures (Roehl et al., 2002). This means that the greater the number of biopsies that are performed, the more accurate the results will be and the less chance of missing detection of cancer. This study cautions clinicians against reducing the number of biopsies even if patients feel that the biopsies are burdensome and will lead to non-compliance.

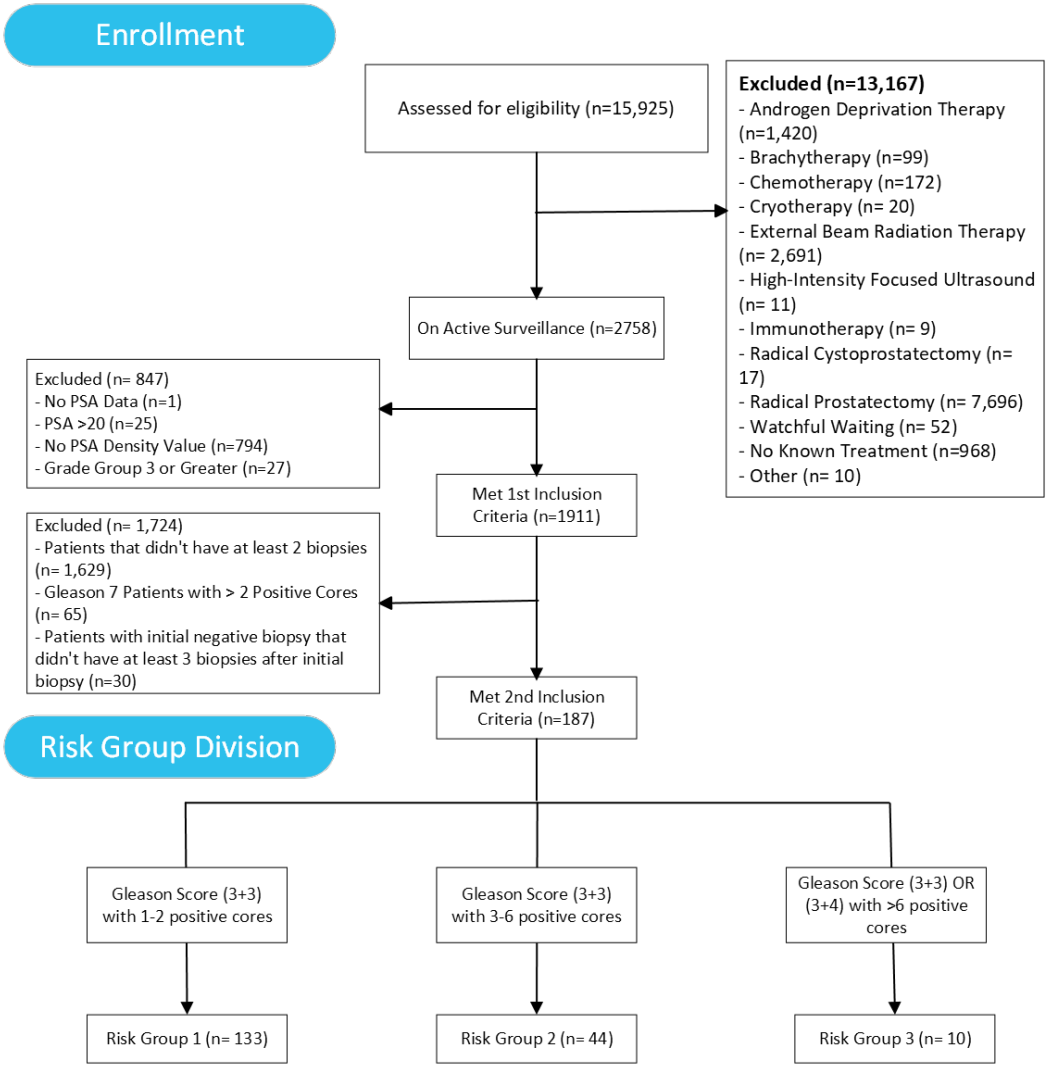
Gap in Research:

Although the pre-existing research is very extensive and indicates potential benefits in reducing the number of biopsy schedules without much impact and decreasing the burden on patients, it does not evaluate the biopsy schedules in terms of appropriate and quality care, complication rates, and negative biopsy incidence. It also does not address patient adherence in conjunction with the time to detection of clinically significant PCa. The purpose of this study is to address this gap to create a form of standardization. This is important to ascertain as PCa cases are on the rise and more patients are opting for AS if they have low-risk PCa. Therefore, this study can assist in clinical decisions about the frequency of patient biopsy schedules to obtain the best outcomes while reducing the risk of complications and burden on the patient. To analyze this, the guiding research question is: What is the impact of low, intermediate, and high-intensity active surveillance regimes on the quality and appropriateness of care for prostate cancer patients on active surveillance? The experiment that this paper will detail involved submitting a data request form to the Pennsylvania Urologic Regional Collaborative (PURC) Data Set to obtain data that pertains to the research question.

Methods

To evaluate the effectiveness of low, medium, and high-intensity biopsy schedules in terms of adherence, early detection, and quality of care, I examined the PURC Database, a partnership of 170 practicing urologists from 13 major urology practices across Pennsylvania, New Jersey, Virginia, and the District of Columbia in a multiyear data-sharing and quality improvement collaborative aimed at advancing the quality of care for men with PCa. This was the most feasible method of data collection as the PURC Data would ensure a large enough population to analyze. A study by Dr. Beckmann, among other studies, with a similar purpose, utilized the Global Action Plan Active Surveillance Prostate Cancer (GAP3) Database

Figure 1. *CONSORT Diagram for Inclusion Criteria*



to determine the risk of transitioning and upgrading to different biopsy schedules (Beckmann et al., 2022). This leads to the conclusion that utilizing a database to obtain data would be the most feasible.

The PURC consortium aims to collect regional prostate biopsy and cancer data to reduce variation in access and care, and track outcomes for PCa and treatments. Eligible participants of the study included men with characteristics consistent with the AS inclusion criteria. This includes men older than 18 years of age who were on AS for the treatment of PCa and had undergone a biopsy that confirmed Grade Group One or Two PCa with less than two positive cores on the index biopsy. Men who were managed on AS but who underwent a radical prostatectomy, hormone treatment, or radiation within one year of the AS start date were excluded from the study because they did not meet the AS criteria. After this, there were two phases of exclusion. The first exclusion criteria included patients diagnosed with Grade Group Three or greater cancer on the index biopsy (n=27). Additionally, patients diagnosed with atypical small acinar proliferation (ASAP) and high-grade prostatic intraepithelial neoplasia (HGPIN) on the index biopsy were excluded from the study. Patients with a PSA greater than 20 (n=25), prostate density of greater than 0.2, and no PSA value (n=794) were also excluded from the study as these patients did not meet the AS criteria and we would be unable to determine eligibility for the study. One patient had no PSA information and was excluded from the study as we were unable to determine eligibility.

The second exclusion criterion excluded patients who did not have at least two biopsies as they did not meet the AS protocol requirements (n=1,629). Additionally, those patients who were Gleason 7 with greater than 2 positive cores were excluded (n=65). Finally, patients who had an initial negative biopsy with less than 3 biopsies after the initial biopsy were excluded (n=30). ***Figure 1*** shows a CONSORT diagram for the inclusion criteria. In total, 187 patients met both inclusion criteria.

Information that was included in the study for each biopsy can be seen in ***Appendix A.*** Patients were then divided into three groups according to the PURC Guidelines which divided patients based on grade group, number of positive cores, maximum percentage of positive cores, and PSA density (***Figure 2***). Additionally, the PURC Guidelines gave recommended biopsy schedules depending on the risk classification (***Figure 3***). There were 133, 44, and 10 patients in Risk Group One (Low-Risk Schedules), Two (Intermediate-Risk Schedules), and Three (High-Risk Schedules), respectively. Of these, 11 patients in Risk Group One, three in Risk Group Two, and one in Risk Group Three had a negative initial biopsy. To adjust for the negative initial biopsy, patients were not considered to be on AS until they had a positive biopsy. This was considered the index biopsy.

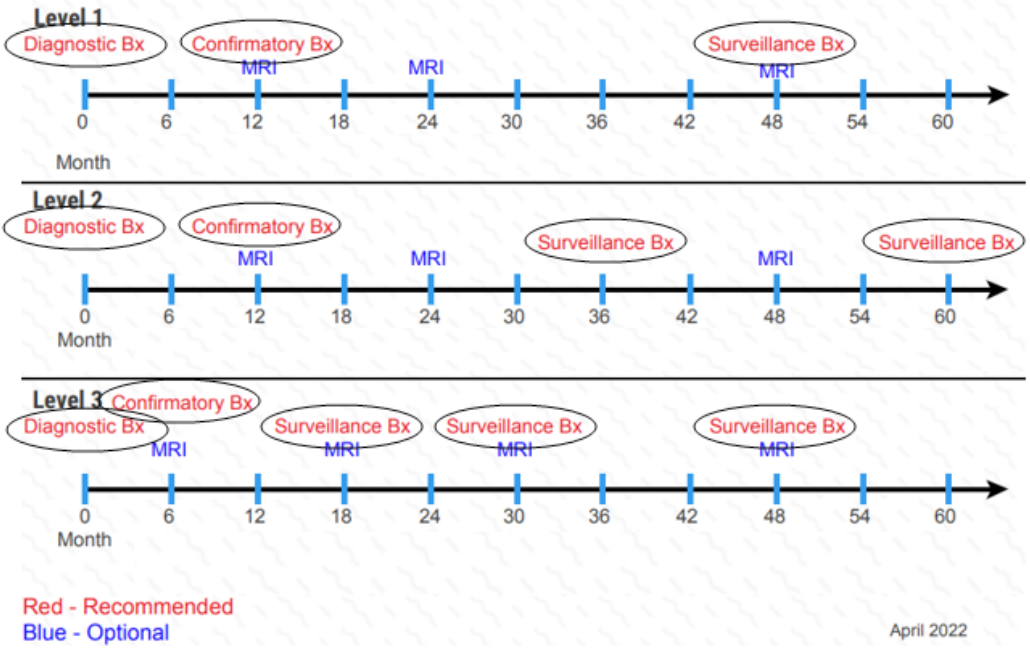
Figure 2*. Image of Low, Intermediate, and High-Intensity Inclusion Criteria according to the PURC Guidelines.*

Reclassification Risk Levels

	Grade Group	# Positive Cores	Max % Core Positive	PSA Density
Level 1	1 AND	≤ 2 AND	≤ 50% AND	≤ 0.15
Level 2	1 AND	3-6 AND	≤ 3 cores > 50% positive AND	≤ 0.2
Level 3	1 AND	> 6 OR	> 3 cores > 50% positive OR	> 0.2
	2 AND	≤ 2 AND	≤ 50% AND	≤ 0.15

PURC is a physician-led quality improvement program aimed at advancing the quality of prostate cancer diagnosis and care. Visit the PURC website for more information: https://hcifonline.org/purc/

***Figure 3**. Image of Low, Intermediate, and High-Intensity Biopsy Schedules according to the PURC Guidelines.*



Results

Once the patients were filtered by the inclusion criteria, basic statistical analysis helped to determine the demographics of the patient population. The participants were all managed by different treatment centers which could lead to differences in the biopsy schedules. The men also varied in age (***Figure 4***), background, and race. The mean age of the participants was 60-79 years of age and the mean PSA was 5.47 µg/L (range 0-18 µg/L). The patient population was 20% African American, 4% Asian, and 73% Caucasian (***Figure 5***).

According to the American Cancer Society, men should start screening for PCa around the age of 50 if they are at moderate risk and at age 45 if they are at high risk which is defined by those that may have a family history of PCa (American Cancer Society, 2023). This graph shows that many individuals may not be screened for PCa soon enough. Still, it is also important to recognize that many individuals may only screen for prostate cancer after symptoms are present.

Regarding other factors such as family history (***Figure 6***), a majority of participants (n=108) had no family history of prostate cancer. The patients who are most likely to need to start biopsies at an earlier stage in life are those who have first-degree relatives with prostate cancer. There were 35 patients with a first-degree relative with prostate cancer and therefore would be at an increased risk for developing prostate cancer.

Finally, it is important to note the type of biopsies participants undergone as some biopsies are more prone to complications (***Figure 7***). Most individuals in the study underwent transrectal ultrasound scan biopsy (TRUS) as it is the standard in most practices. There were no 30-day complications in the study that required hospitalization.

Figure 4. *Bar Graph of Age Distribution of Participants*

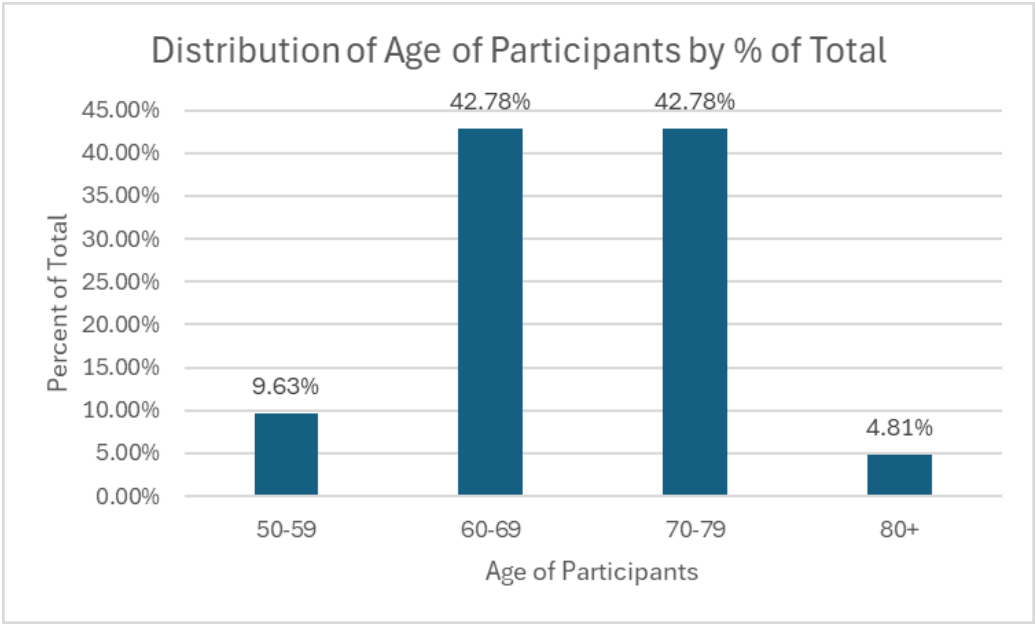


Figure 5. *Graph of Race Breakdown of Participants*

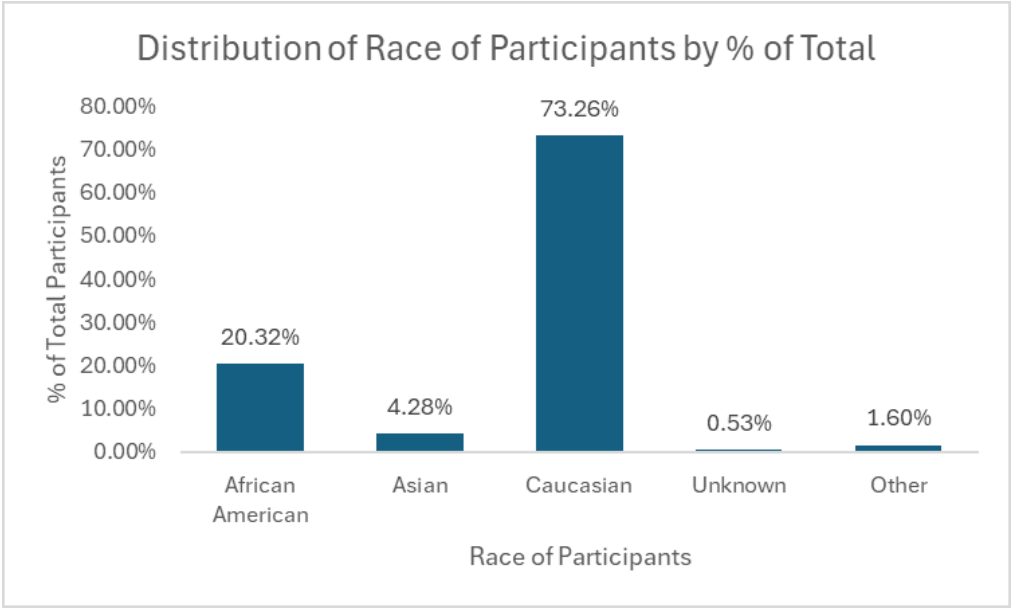


Figure 6. *Graph of Family History of Participants*

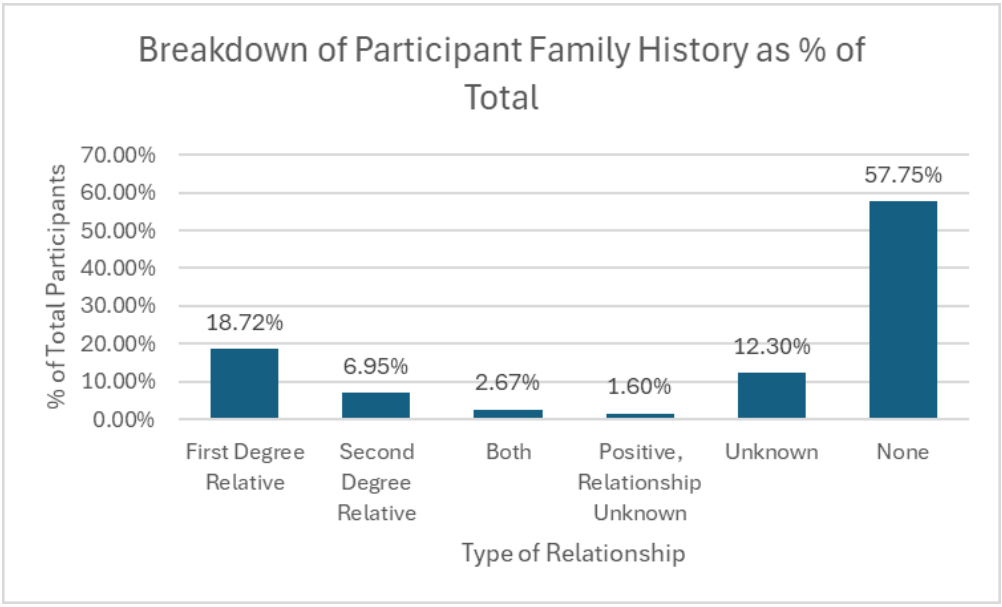
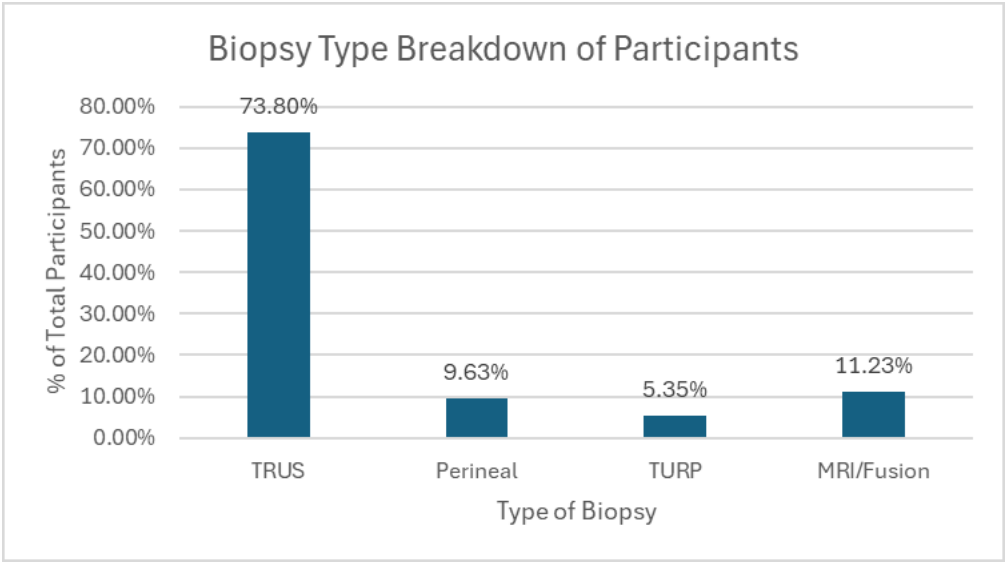


Figure 7. *Graph of Biopsy Type Breakdown by Participants*



Discussion

After this, we further analyzed the effectiveness of the biopsy schedules through multiple factors: Appropriateness and Quality of Care, Negative Biopsy Rate, Time to Detection of Significant Cancer, and Staging of Cancer to answer the research question from different perspectives and address the gap.

Appropriateness and Quality of Care

To determine whether the three biopsy schedules provide appropriate and quality care, adherence to the established schedules was analyzed. The PURC schedules call for an index biopsy, a confirmatory biopsy, and surveillance biopsies at specific months in each schedule. To determine the adherence and account for uncontrollable factors such as scheduling issues, if patients had their biopsy ±3 months of the required biopsy month, they were considered to adhere to their schedule.

In Risk Group 1 (Low-intensity), the biopsy schedule calls for patients to undergo an index biopsy, then a confirmatory biopsy at 12 months, and a surveillance biopsy at 48 months. Of the 133 patients, 46 patients (35.4%) adhered to their schedule at the confirmatory biopsy, and 10 (7.5%) patients adhered to their schedule at the 48-month surveillance biopsy.

In Risk Group Two (Intermediate-intensity), the biopsy schedule calls for patients to undergo an index biopsy, a confirmatory biopsy at 12 months, and surveillance biopsies at 36 and 60 months. Of the 44 patients, 18 patients (40.9%) adhered to their schedule at the confirmatory biopsy, 7 (15.9%) adhered to the 36-month surveillance biopsy, and 0 (0.0%) adhered to the 60-month adherence biopsy.

In Risk Group Three (High-intensity), the biopsy schedule calls for patients to undergo an index biopsy, a confirmatory biopsy at 6 months, and surveillance biopsies at months 18, 30, and 48. Of the 10 patients on this schedule, three (30%) adhered to the confirmatory biopsy, then 0 (0.0%) adhered to the surveillance biopsies for months 18, 30, and 48.

Overall, patients were most likely to adhere to the intermediate-intensity schedule at the confirmatory biopsy and the first surveillance biopsy, leading to the conclusion that this schedule provides the most patient-preferred care for its patient population. This also shows that the low-intensity and highest-intensity biopsy schedules may not be the best schedules to achieve patient compliance. The low-intensity schedule may have too few biopsies and too much time between the biopsies, allowing for possible loss of follow-up or conversion to other follow-up schedules or treatment options. Additionally, the high-intensity schedules may be too burdensome for patients as they require biopsies more frequently, causing patients to drop the biopsy schedule and either convert to a less intense schedule or to a different treatment option. To accommodate for the burden, it may be possible to rely more on prostate MRIs as an imaging option as they do not have as many complications but may need to be developed further. To fully determine if these biopsy schedules are effective, it is important to also look at the negative biopsy incidence rate.

Negative Biopsy Rate

To calculate the effectiveness of each biopsy schedule in terms of the negative biopsy rate, we first calculated the negative predictive value (NPV) for each biopsy and then compared it to the positive prevalence for the same biopsy (***Figure 8***).

In Risk Group One, the NPV value is slightly lower but relatively close to the positive prevalence value which suggests that the biopsy is effectively identifying patients with prostate cancer, indicating an appropriate level of biopsying in the Risk Group One patient population. In Risk Group Two, the NPV Value is significantly smaller than the positive prevalence value which suggests that the biopsy schedule may be under-biopsying and may be missing a considerable number of patients with prostate cancer for the Risk Group Two patient population. Finally, in Risk Group Three, the NPV Value is slightly smaller but relatively close to the positive prevalence value, indicating that the biopsying schedule is effective and appropriate for that specific patient population.

Overall, this shows that it is possible to tailor the biopsy schedule to the prostate cancer disease risk by reducing the number of biopsies. It is important to keep in mind though, that in the high-intensity group, reducing the number of biopsies may lead to missed diagnoses, as the intermediate-intensity group was seen to be under-biopsying the patients, which is where other imaging options such as prostate MRIs may be used to bridge the gap.

Figure 8. *Comparison of Positive Prevalence to Negative Predictive Value*

		Index Biopsy	Confirmatory Biopsy	Surveillance Biopsy 1	Surveillance Biopsy 2
Risk Group 1	Positive Prevalence	N/A	0.526	0.586	N/A
	NPV	N/A	0.474	0.414	N/A
Risk Group 2	Positive Prevalence	N/A	0.909	0.864	0.667
	NPV	N/A	0.091	0.136	0.333
Risk Group 3	Positive Prevalence	N/A	0.6	0.6	1
	NPV	N/A	0.4	0.4	0

Time to Detection of Significant Cancer

In this study, clinically significant cancer was defined as Gleason (3+4) or Gleason (4+3). When clinically significant cancer was detected, the time to detection was determined by the days between the index biopsy and the biopsy in which the clinically significant cancer was detected. In Risk Group 1, the average time to clinically significant detection was 1003.6 days. In Risk Group 2, the average time to clinically significant detection was 878.3 days. In Risk Group 3, the average time to clinically significant detection was 691 days. Risk Group 3 had the most frequent biopsy schedule and despite the lower adherence, the lowest time to detection shows that there is some merit to the schedule and it should not be completely disregarded. These results highlight the value of reducing the biopsy burden in patients with low and intermediate risk of developing clinically significant prostate cancer. Moreover, the increased intensity of the high-burden schedule does help identify those patients in the high-risk group that will develop clinically significant prostate cancer.

Conclusion

Overall, by looking at the three factors together, patient adherence was best in the intermediate-frequency schedule, the negative biopsy rate was lowest in the low-frequency and highest-frequency schedule, and the high-frequency schedule had the lowest time to detection of clinically significant prostate cancer.

This ultimately shows that each biopsy was effective in different facets. Although the Group 1 and Group 2 schedules are less burdensome on patients, making them easier to adhere to, the Group 3 schedule leads to better clinical outcomes due to more frequent biopsies. This leads to a need for further research to determine an ideal schedule - a schedule

between those of Group 2 and Group 3 - to ensure that patients do not find it burdensome to adhere to, but one in which the cancer is detected early.

Limitations

The study was limited by multiple factors. First, the number of patients in each Risk Group was not equal. To increase the validity of the results, future research should include equal numbers of participants in each group with a much larger sample size for each individual group. Additionally, many of the patients in Risk Groups 2 and 3 did not have as many biopsies as the schedule required. Risk Group 2 requires four biopsies, while Risk Group 3 requires five biopsies. Only six patients met the four biopsy criteria for Risk Group 2 and zero patients met the five biopsy criteria for Risk Group 5; therefore, in order to adjust for low numbers, the study only required patients to have three biopsies. To increase the validity of the results, the patients should undergo as many biopsies as the schedule requires. Despite this, each schedule was seen to have its own merits and limitations, showing the need for further research with further intermediate schedules to find the ideal biopsy schedule and create a protocol.

Next Steps

The role of prostate imaging via, multiparametric MRI, could also allow us to avoid biopsies in a significant number of patients to reduce the burden and risk of complications while at the same time balancing the risk of developing more aggressive cancer. Similar to other malignancies, there may be a time when patients only get biopsies if imaging shows a change, but additional investigations need to be done in order to determine the extent.

Additionally, as seen through this study, a better protocol is needed for biopsy schedules to increase adherence and outcomes. This study focuses on a primarily Caucasian community from Pennsylvania, New Jersey, Virginia, and the District of Columbia where, according to the National Institute on Minority Health and Health Disparities, the average median income for Caucasians is above $100,000 and 52.8% have more than a bachelor's degree. There is still a potential for better clinical outcomes in this population where there is, potentially, access to above-average resources. As seen in a study by Steven Coughlin in which he examined the relationship between socioeconomic status and prostate cancer survival, there are well-documented disparities in prostate cancer survival by socioeconomic status, race, education, and census tract–level poverty (Coughlin, 2020). From this, we can see a need for further investigation of these protocols to improve outcomes for not only the study population, but also for a minority population where prostate cancer cases are most prevalent, the median income is around $60,000, and only around 23% have more than a bachelor's degree. By improving biopsying protocols, we can not only create health equality but also health equity for all patients.

Acknowledgement

The author wishes to thank Dr. Andres Correa – without his mentorship, this study would not be possible.

Appendix A- Initial Data Set Variables More Information

Description	Values	Type
Encrypted Patient ID		INTEGER
Race	1 - African American 2 - Asian 3 - Native American 4 - Caucasian 5 - Native Hawaiian/Pacific Islander 6 - Unknown/Refused 7 - Other	INTEGER
Ethnicity	1 - Non-Hispanic 2 - Hispanic 3 - Unknown/Refused	INTEGER
Biopsy Type	1 - TRUS 2 - Perineal 3 - TURP 4 - MRI/Fusion (retired July 2022) 5 - Transrectal/Targeted 6 - Transperineal/Targeted	INTEGER
Age Range	Below 49 50-59 60-69 70-79 80+	RANGE

Family History	1 - First Degree Relative (Father, Brother, Son) 2 - Second Degree Relative (Other Relative) 3 - Both 4 - Positive, Relation Unknown 5 - Unknown 6 - None	INTEGER
AS Start Date		DATE
Days between start date and 1st biopsy		INTEGER
1st Biopsy Date		DATE
Biopsy Result	1 - Positive 2 - Negative	INTEGER
1st Gleason	3	INTEGER
2nd Gleason	3 OR 4	INTEGER
Gleason Score	(3+3) OR (3+4)	EXPRESSION
# of Positive Cores		INTEGER
Total Cores		INTEGER
Max % Core Positive		PERCENTAGE
PSA Date		DATE
PSA value		INTEGER
Prostate size		INTEGER
PSA Density		INTEGER
2nd Biopsy Date		DATE
Days between 2nd and Initial		INTEGER
Biopsy Result	1 - Positive 2 - Negative	INTEGER
1st Gleason	3	INTEGER
2nd Gleason	3 OR 4	INTEGER
Gleason Score (3+3) (3+4) (4+3)	(3+3) OR (3+4)	EXPRESSION

# of Positive Cores		INTEGER
Total Cores		DATE
Max % Core Positive		PERCENTAGE
PSA Date2		DATE
PSA value		INTEGER
Prostate size		INTEGER
PSA Density		INTEGER
3rd Biopsy Date		DATE
Days between 3rd and Initial		INTEGER
Biopsy Result	1 - Positive 2 - Negative	INTEGER
1st Gleason	3	INTEGER
2nd Gleason	3 OR 4	INTEGER
Gleason Score (3+3) (3+4) (4+3)	(3+3) OR (3+4)	EXPRESSION
# of Positive Cores		INTEGER
Total Cores		INTEGER
Max % Core Positive		PERCENTAGE
PSA Date3		DATE
PSA value		INTEGER
Prostate size		INTEGER
PSA Density		INTEGER
4th Biopsy Date		DATE
Days Between 4th and Initial		INTEGER
Biopsy Result	1 - Positive 2 - Negative	INTEGER
1st Gleason	3	INTEGER
2nd Gleason	3 OR 4	INTEGER
Gleason Score (3+3) (3+4) (4+3)	(3+3) OR (3+4)	EXPRESSION

# of Positive Cores		INTEGER
Total Cores		INTEGER
Max % Core Positive		PERCENTAGE
PSA Date4		DATE
PSA value		INTEGER
Prostate size		INTEGER
PSA Density		INTEGER
5th Biopsy Date		DATE
Days Between 5th and Initial		INTEGER
Biopsy Result	1 - Positive 2 - Negative	INTEGER
1st Gleason	3	INTEGER
2nd Gleason	3 OR 4	INTEGER
Gleason Score (3+3) (3+4) (4+3)	(3+3) OR (3+4)	EXPRESSION
# of Positive Cores		INTEGER
Total Cores		INTEGER
Max % Core Positive		PERCENTAGE
PSA Date5		DATE
PSA value		INTEGER
Prostate size		INTEGER
PSA Density		INTEGER
6th Biopsy Date		DATE
days between 6th and initial		INTEGER
Biopsy Result	1 - Positive 2 - Negative	INTEGER
1st Gleason	3	INTEGER
2nd Gleason	3 OR 4	INTEGER
Gleason Score (3+3) (3+4) (4+3)	(3+3) OR (3+4) OR (4+3)	EXPRESSION

# of Positive Cores		INTEGER
Total Cores		INTEGER
Max % Core Positive		PERCENTAGE
PSA Date6		DATE
PSA value		INTEGER
Prostate size		INTEGER
PSA Density		INTEGER

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