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Racialized Geographies of Pain: Structural Barriers to Hospice Utilization for Prostate Cancer Decedents, 1999-2020

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Abstract

Background

Despite a two-decade expansion of hospice care in the United States, racial disparities in end-of-life care for advanced prostate cancer remain entrenched and cannot be explained by socioeconomic status alone. Grounded in the theoretical framework of "racialized geographies of pain," this study investigates the structural barriers contributing to these disparities, specifically examining the "Urban-Insurance Paradox" where high resource availability does not translate to equitable care for Black men.

Methods

We analyzed a national cohort of 464,142 prostate cancer decedents using the Centers for Disease Control and Prevention (CDC) WONDER database (1999–2020). To address data suppression in minority groups, we employed a novel truncated Poisson Monte Carlo simulation. We utilized logistic regression to calculate adjusted odds ratios (aOR) for institutional death and Sankey flow analysis to visualize temporal transitions in the place of death. Additionally, we assessed the impact of Medicare Advantage (MA) penetration on racial gaps in care utilization using generalized linear models.

Results

We identified a distinct "Urban-Insurance Paradox": although 96.9% of Black decedents resided in medical resource-dense metropolitan areas with high MA penetration, their adjusted risk of institutional death remained significantly higher than White decedents (aOR=1.73). Sankey analysis indicated that the de-institutionalization process for Black men lagged approximately 10 years behind that of White men. Crucially, while MA market expansion facilitated racial convergence in the utilization of professional hospice facilities (narrowing the gap to 0.2%), it failed to disrupt the "Parallel Retention" of Black men in acute care settings, with the racial gap in institutional death rates locked at approximately 11 percentage points.

Conclusions

Market mechanisms alone are insufficient to penetrate deep-seated structural inertia. For Black men, high institutional reliance represents a rational adaptation to "hospice deserts" lacking community-based pain management infrastructure. De-institutionalization does not simply equate to "de-pain" but signifies a redistribution of structural risk from institutions to communities. Health policy must urgently shift towards place-based interventions, such as establishing "Pain Management Enterprise Zones," to address structural inequities embedded in spatial geographies.

Introduction

Prostate cancer ranks as the second leading cause of cancer death among U.S. men, exhibiting some of the most profound racial disparities in oncology.(1,2)For patients with metastatic castration-resistant

prostate cancer (mCRPC), the terminal phase is frequently marked by severe bone metastasis-induced pain, elevating high-quality hospice care and pain management from a mere medical service to a fundamental human right. Over the past two decades, the U.S. has witnessed a "Hospice Movement," shifting the locus of death from hospitals to homes or specialized facilities—recent data indicates a surge in hospice facility deaths among prostate cancer decedents from 0.5% in 2003 to 10.3% in 2020.(3–6)Yet, whether this palliative progress has equitably benefited all demographic groups, particularly against the dual backdrop of the opioid crisis and Medicare market reforms, remains an unresolved question.(7–11)

Despite the overall uptake in hospice utilization, Black men disproportionately rely on acute hospital care at the end of life. Jatwani et al. highlight that even amidst a general decline in hospital mortality, Black men sustained a significantly higher rate of hospital death (21.3%) compared to White men (13.7%) as of 2020, bearing a heavier burden of unmitigated pain.(6,12–14) Existing literature often employs a "Deficit Model," attributing such disparities to patient-level factors like lower socioeconomic status (SES), lack of advance directives, or cultural "medical mistrust".(10,15,16) However, these individual-centric explanations fail to resolve a core paradox: Why do Black patients continue to face significant barriers to hospice access even after controlling for income and within resource-dense metropolitan areas?(17)This necessitates transcending individual behaviors to scrutinize the deep-seated structural forces constraining their end-of-life choices.(18)

This study proposes the theoretical framework of "Racialized Geographies of Pain," positing that race is not merely a demographic variable but a spatial construct.(18)The history of residential segregation in the U.S. has racialized the distribution of medical resources, generating "Hospice Deserts"—high-mortality areas characterized by a scarcity of hospice facilities and stringent opioid controls.(19,20)Within this structural context, we utilize the place of death of prostate cancer decedents as a proxy measure for "Spatial Justice." We hypothesize that the high rate of institutional death among Black patients stems not from cultural preference, but represents a rational adaptation to the spatial mismatch of "high demand versus low resources".(21–24)

To test this hypothesis, we constructed a nationwide cohort of over 460,000 prostate cancer decedents from 1999 to 2020 using CDC WONDER and CMS databases. Spanning a 21-year period to capture the dynamic impact of policy shifts, we incorporated Medicare Advantage (MA) penetration as a marketization indicator to address two pivotal questions: (1) Is there a racialized mismatch between residential segregation and the geographic distribution of hospice resources? (2) Is the expansion of the insurance market sufficient to break the structural dependence of Black patients on acute care? By revealing the "Urban-Insurance Paradox," this study aims to redefine racial inequalities in prostate cancer end-of-life care through the lens of structural violence.

Methods

2.1 Study Design and Data Sources

We employed a population-based retrospective cohort design to analyze the place of death for prostate cancer decedents aged 65 years and older in the United States from 1999 to 2020. The dataset was constructed by triangulating three national administrative databases:1)Mortality Data: Extracted from the Centers for Disease Control and Prevention (CDC) WONDER Compressed Mortality File,(25)providing county-level annual death counts and demographic characteristics.2)Insurance Market Data: Obtained from the Centers for Medicare & Medicaid Services (CMS) annual Medicare Advantage (MA) Penetration Files,(26) used to quantify county-level coverage of the privatized insurance market.3)Social Determinants Data: Sourced from the Health Resources and Services Administration (HRSA) Area Health Resources Files (AHRF) to extract county-level socioeconomic status (SES) and healthcare resource supply variables.(27) This study utilized only de-identified aggregate data and was exempted from Institutional Review Board (IRB) review in accordance with the Common Rule.

2.2 Study Population

The cohort included male decedents with an underlying cause of death encoded as prostate cancer (ICD-10 code: C61). The study population was restricted to individuals aged ≥65 years to ensure eligibility for Medicare coverage, thereby granting direct explanatory power to the MA penetration rate variable. Grounded in the theoretical framework of "Racialized Geographies of Pain," the analysis focused on Non-Hispanic Black (hereafter "Black") and Non-Hispanic White (hereafter "White") men to juxtapose structural racial disparities.

2.3 Measures and Definitions Outcome Variable: Place of Death

We reconstructed the place of death into a "Three-Tier Care Model" reflecting accessibility to pain management:

Tier 1 (Proactive Hospice Care): Defined as death within a specialized Hospice Facility. This represents access to specialized pain management and end-of-life support.

Tier 2 (Reactive Institutional Care): Defined as death within a medical facility (Inpatient Hospital/Emergency Room) or Nursing Home. This signifies a structural dependence on the acute care system.

Tier 3 (Home/Potential Risk): Defined as death at Home. Due to data limitations distinguishing the presence of home hospice services, this tier is regarded as a highly heterogeneous outcome. In the absence of explicit service markers and contextualized by our geographic analysis, we conceptualized this tier as a potential "structural risk space" for pain management.

Explanatory Variables

Race: Following social epidemiology conventions, race was operationalized not as a biological variable, but as a social and political construct, serving as a proxy for exposure to systemic racism and residential segregation.

MA Penetration Rate: Defined as the proportion (0-100%) of eligible Medicare beneficiaries enrolled in MA plans per county, included as a continuous variable.

Covariates Control variables included county-level median household income, poverty rate, and Rural-Urban Continuum Codes (RUCC) based on USDA standards. Period effects were controlled using a dichotomous variable (1999-2009 Baseline Period vs. 2010-2020 Expansion Period).

2.4 Handling Data Suppression via Simulation

To address the data suppression imposed by CDC WONDER on small-sample counties (N < 10) and prevent the systematic exclusion of low-density rural or minority-populated areas, we developed a Truncated Poisson Monte Carlo Simulation method:1)Predicting Expected Values (λ): We first trained a Quasi-Poisson regression model using unsuppressed data to predict the expected death countλfor suppressed units based on covariates.2)Random Sampling**:** We performed Monte Carlo sampling (n=1,000) for each suppressed unit.3)Logical Truncation: Generated values were strictly truncated within the [0, 9] interval to adhere to the logical rules of data suppression.The calibration plot demonstrated robust goodness-of-fit in the low-probability range, and the distribution of imputed data aligned with the expected right-skewed pattern (Supplement Material 1, eFigure 1 and eFigure 2).

2.5 Statistical Analysis

To account for overdispersion in count data, we employed Quasi-binomial Generalized Linear Models (GLM) to estimate the adjusted Odds Ratios (aOR) and 95% Confidence Intervals (CI) for death probabilities across each tier.1)Main Model: Adjusting for Period Fixed Effects and other covariates, we specifically examined Race, MA Penetration Rate, and their interaction term (Race × MA_Rate) to test the moderating effect (convergence or divergence) of market expansion on racial disparities (Supplement Material 2, eTable 1).2)Sensitivity Analysis: We conducted sensitivity testing on the definition of Tier 2 by constructing separate models for "Hospital Only" versus "Hospital + Nursing Home." The results indicated that the institutional death gap between Black and White decedents remained stable at approximately 11 percentage points regardless of definition stringency, confirming the robustness of our findings (Supplement Material 2, eTable 2).All statistical analyses were performed using R software (version 4.4.2), with a two-sided *P*-value < .05 considered statistically significant.

Results

Study Population Characteristics and Secular Trends

The final study cohort comprised 464,142 prostate cancer decedents aged 65 years and older from 1999 to 2020(Table 1). This included 223,507 White and 38,265 Black decedents in the Baseline Period (1999-2009), and 172,709 White and 29,661 Black decedents in the Expansion Period (2010-2020). Across both periods, the county-level environments of Black and White decedents exhibited distinct disparities. Regarding rural-urban distribution, Black decedents were markedly concentrated in metropolitan areas;

during the Expansion Period, only 3.1% of Black decedents resided in rural areas, a proportion significantly lower than that of White decedents (13.6%). In terms of health insurance and economic profile, although Black decedents lived in counties with consistently higher poverty rates (16.9% vs. 13.6% in the Expansion Period) and lower median household incomes ($56,191 vs. $59,917), the Medicare Advantage (MA) penetration rate in their residential areas was marginally higher than that for White decedents (33.6% vs. 32.5%).

Between 1999 and 2020, both racial groups underwent a structural shift in the distribution of place of death, yet absolute racial disparities persisted:1)Hospital Death: A downward trend in hospital deaths was observed regardless of race. The proportion declined from 27.8% to 17.6% for White decedents and from 41.6% to 29.4% for Black decedents between the Baseline and Expansion periods. Despite the significant reduction among Black men, their hospital death rate remained 11.8 percentage points higher than that of White men in the Expansion Period.2)Hospice Facility: Utilization of specialized hospice facilities surged for both groups. Rates increased from 2.6% to 11.6% among White decedents and from 1.9% to 10.4% among Black decedents. By the study endpoint, the crude proportion of deaths occurring in hospice facilities was comparable between Black and White decedents, with a gap of only 1.2 percentage points.3)Home Death: The proportion of home deaths for White decedents remained stable at approximately 70% across both periods (69.5% to 70.8%). In contrast, although the rate for Black decedents rose from 56.0% to 60.2%, it consistently remained below the level observed for White decedents.

Temporal Evolution of Care Patterns

Joinpoint regression analysis unveiled distinct temporal trajectories for the three places of death from 1999 to 2020, characterized by marked parallelism and divergence across racial groups (Figure 1).

Persistent Decline in Institutional Death (Tier 2). As the least favorable outcome, institutional deaths (hospital and nursing home) exhibited a significant downward trend for both races, reflecting the widespread dissemination of palliative care principles. For White decedents, the institutional death rate decreased from 60.65% in 1999 to 33.94% in 2020. Joinpoint analysis identified two distinct phases of decline: a steady decrease from 2002 to 2018 (APC = -2.53%, P<.05), followed by an accelerated decline from 2018 to 2020 (APC = -5.64%, P<.05). Similarly, the rate for Black decedents fell from 67.28% in 1999 to 44.31% in 2020. However, despite this downward trajectory, Black decedents exhibited only a single, long-term linear descent (2002-2020 APC = -2.16%, P<.05), lacking the late-stage acceleration observed in their White counterparts. Consequently, although the curves remained parallel, the institutional death rate for Black men was consistently higher throughout the study period (Figure 1A, Upper Panel).

Steady Rise in Home Death (Tier 3). Concomitant with the reduction in institutional deaths, home death gradually emerged as the dominant modality. White decedents saw their home death rate rise continuously from 35.12% in 1999 to 51.94% in 2020. This growth significantly accelerated after 2018, with the APC surging from 1.31% to 7.71% (P<.05). Black decedents also showed an increasing trend (29.34% in 1999 to 45.32% in 2020). Notably, a "catch-up effect" was observed, particularly from 2018 to

2020, where the APC reached 6.54% (*P*<.05). Nonetheless, the home death rate for Black decedents remained lower than that for White decedents in every observed year (Figure 1A, Lower Panel).

The Rise and Fall of Hospice Facilities (Tier 1). The utilization of specialized hospice facilities displayed a unique "Inverted V-shaped" trend (Figure 1B). During the rapid expansion phase, the early 2000s witnessed explosive growth in facility use, with APCs reaching as high as 179.6% for White decedents (2003-2005) and 66.7% for Black decedents (2003-2007). Alarmingly, a recent reversal occurred at the end of the study period. White decedents experienced a notable decline from 2018 to 2020 (APC = -10.4%, *P*=.078). For Black decedents, the downturn was even more precipitous and onset earlier, shifting from ascent to descent at a rate of -12.6% per year starting in 2017 (*P*<.05). This resulted in utilization rates falling below 10% for both groups by 2020 (9.46% for White, 7.12% for Black).

Figure 1. Temporal Trends in End-of-Life Care Utilization for Prostate Cancer Decedents by Race, 1999-2020. A. Trends in Reactive & Unsupported Care (1999-2020). B.Trends in Proactive Hospice Care (2003-2020).

Ecological Transition and Structural Lag in Place of Death

To visualize the structural reconfiguration of place of death between the two periods, Figure 2 depicts the ecological flow from the Early Period (1999-2010) to the Recent Period (2010-2020).

Racial Disparities in De-institutionalization. While both groups exhibited a distinct trend toward "de-institutionalization," the phenomenon of "Institutional Retention" among Black men remained pronounced. For White men, the proportion of institutional deaths (Tier 2, gray block) was substantially compressed from 51.8% in the Early Period to 34.5% in the Recent Period. This indicates that while more than half of White decedents died in institutions historically, this figure has now fallen to approximately one-third. In contrast, for Black men, although the proportion of institutional deaths also declined from 61.3% to 44.5%, their current level (44.5%) remains comparable to the level observed for White men a decade ago (51.8%). This comparison strongly suggests that Black men experience an approximate 10-year structural lag in the process of decoupling from hospital death.

Substitution Effects of Hospice and Home Death. The reduction in institutional deaths translated into gains for Tier 1 and Tier 3, yet with distinct allocation patterns. Hospice Facility (Tier 1) growth was similar in magnitude across racial groups, with rates increasing from 2.7% to 12.1% for White men and from 2% to 10.6% for Black men. However, the disparity was primarily manifested in Home Death (Tier 3). In the Recent Period, 53.4% of White men achieved home death, establishing it as the dominant modality. Conversely, the rate for Black men was 44.8%, reaching near parity with their institutional death rate (44.5%). This demonstrates that for Black men, the hospital remains a primary end-of-life setting of equal weight to the home, whereas for White men, the home has established clear dominance.

3.4 Spatial Inequity: The Mismatch of Burden and Resources

Geospatial analysis (Figure 3) revealed a distinct "inverse care" pattern between the mortality burden of prostate cancer and the availability of hospice resources.

Racialized Mortality Clusters. Source data analysis indicated a high degree of spatial concentration in prostate cancer mortality among Black men. High-mortality counties were predominantly clustered in two geographically distinct regions: The Southern Black Belt, a contiguous band of counties extending along the Mississippi River Valley to North Carolina, encompassing substantial portions of Mississippi (MS), Alabama (AL), and Georgia (GA); and Hyper-segregated Metros, specific urban centers in the North and Midwest, such as Cook County (IL, Chicago), Wayne County (MI, Detroit), and Philadelphia County (PA). These areas constituted "islands" of high Black mortality density amidst surrounding low-burden White counties. In sharp contrast, the mortality distribution for White men was spatially diffuse, covering the vast majority of U.S. counties more homogeneously.

Overlap with Hospice Deserts. The superposition of mortality maps and hospice utilization maps exposed an alarming "Spatial Mismatch." This manifested primarily as a "High Demand–Low Utilization" Trap: in the aforementioned high-burden Black regions, hospice facility utilization rates were universally critically low. Particularly in the rural South, utilization rates in many high-mortality counties remained below 5%, effectively characterizing these regions as "Hospice Deserts"—a pattern that persisted even after correcting for small-sample suppression via our imputation method. Furthermore, the analysis revealed a Persistent Geographic Disadvantage. A comparison between the 1999-2010 and 2010-2020 periods revealed that, despite the nationwide uptick in overall hospice utilization, this pattern of spatial deprivation in the "Southern Lowlands" and "Inner Cities" exhibited profound "structural stickiness," remaining fundamentally unaltered over time.

3.5 Racialized Marginal Effects of Market Expansion

Predicted probability analysis derived from the GLM model revealed that Medicare Advantage (MA) penetration exerts significantly heterogeneous moderating effects across different care tiers, manifesting a dual character of "Convergence-Retention" (Figure 4, 5).

Tier 1 (Hospice Facility): Significant Racial Convergence. Market expansion demonstrated a clear "catch-up effect" in the utilization of specialized hospice facilities. In a hypothetical scenario with 0% MA penetration, the predicted utilization rate was 1.60% for White men compared to only 0.70% for Black men, indicating a significant gap of 0.9 percentage points. However, as MA penetration rose to 60%, the racial gap underwent a structural contraction. The predicted probability for Black men steadily increased to 0.94%, whereas it slightly decreased to 1.15% for White men. This inverse slope dynamic reduced the racial gap from 0.9% in low-MA areas to a remarkably narrow 0.21% in high-MA areas, suggesting that high-penetration insurance markets facilitate the removal of barriers for Black men accessing professional hospice institutions.

Tier 2 (Institutional): Parallel Structural Retention. In sharp contrast to the convergence observed in Tier 1, institutional deaths (hospital/nursing home) exhibited stubborn path dependence. Although higher MA

penetration was associated with lower institutional death rates for both races (White: 24.9% to 21.4%; Black: 36.5% to 32.2%), the two predicted curves remained nearly parallel. Regardless of the degree of market penetration, the absolute difference between Black and White decedents remained locked at approximately 11 percentage points (11.58% at 0% MA vs. 10.86% at 60% MA). This indicates that insurance market expansion alone failed to dismantle the structural dependence of Black patients on the acute care system, as market mechanisms did not touch the deep-seated roots of institutional retention.

Tier 3 (Home): Stable Care Divide. Home death patterns presented a third morphology: a stable divide. While increased MA penetration universally elevated the probability of home death, the rate for White men consistently remained 7-9 percentage points higher than that for Black men across all MA levels. This pattern of "synchronous elevation with constant disparity" implies that the realization of a good death at home may depend more on non-insurance determinants, such as household wealth and social support, rather than market penetration alone.

Discussion

4.1 Structural Risk Redistribution under De-institutionalization

Our study demonstrates a significant de-institutionalization shift in the place of death for U.S. prostate cancer decedents. This observation aligns with a recent analysis by Jatwani et al., which documented a general decline in hospital deaths and a surge in hospice facility utilization for prostate cancer over the past two decades.(6)However, our granular analysis reveals that this transition is markedly asynchronous across racial groups. Although the proportion of home deaths among Black men has increased over time, their risk of retention in institutional care (hospitals/nursing homes) remains significantly higher than that of White men after adjusting for socioeconomic and rural-urban factors, with the overall de-institutionalization process lagging by approximately a decade. From the perspective of "Racialized Geographies of Pain," the place of death is not merely a medical outcome but an institutional product shaped by the interplay of long-term residential segregation and the spatial allocation of medical resources.(28,29)

These findings challenge the linear narrative equating "home death" with a "good death." In resource-rich areas, home death often signifies an extension of professional hospice care and pain management; conversely, in resource-deprived regions, exiting an institution may not imply entering a care environment capable of symptom control, but rather exposure to a "structural risk space" lacking professional support.(30)Here, de-institutionalization does not represent a unidirectional improvement but likely signifies a redistribution of risk from the institutional setting to the community space.

4.2 Limits of Insurance Expansion: Convergence without Release

Analysis of Medicare Advantage (MA) penetration further illuminates the structural boundaries of market expansion. As MA penetration increased, the racial gap in the utilization of specialized hospice facilities (Tier 1) narrowed significantly, indicating that lowering payment barriers indeed improved access to high-

end services. However, this convergence was not accompanied by a synchronous decline in dependence on acute institutional care (Tier 2); the proportion of Black men dying in hospitals or nursing homes remained consistently higher than that of White men, with the gap persisting over time. In this sense, the higher institutional death rate among Black patients should be understood as a "rational adaptation" to the spatial mismatch of "high demand versus low resources," rather than a result of cultural preferences or information deficits. This pattern of "Convergence without Release" suggests that insurance expansion has not reshaped the overall trajectory of end-of-life care. For patients in chronically under-resourced communities, even if formal coverage is achieved, the lack of community-based pain management infrastructure continues to funnel them into acute care settings. Consequently, emergency and inpatient care function not merely as medical choices but as rational coping mechanisms formed under structural constraints.

4.3 Spatial Inequity and the Institutional Implications of "Double Jeopardy"

Geographic analysis further demonstrates that the spatial overlap of high mortality burden and low hospice penetration is not randomly distributed but highly concentrated in regions with histories of long-standing racial segregation and institutional disinvestment. These "Hospice Deserts" are not mere voids of service but spatial manifestations of chronic structural neglect.(31)In these regions, terminal patients face a "Double Jeopardy": higher disease burden compounded by weaker community care capacity. Against this backdrop, the rise in home deaths may not reflect improved quality of care, but rather pointing to patients exiting institutions into living spaces devoid of pain control and professional support. Therefore, this study emphasizes that driving de-institutionalization through insurance expansion alone, without addressing the spatial dimension, may inadvertently exacerbate structural inequalities in end-of-life care.(32)

4.4 Policy Implications: From Insurance Coverage to Spatial Care Capacity

Our findings compel a critical rethinking of the current end-of-life policy framework centered on insurance expansion. Over the past two decades, U.S. reforms have largely relied on mechanisms like Medicare Advantage to lower payment barriers, assuming that expanded coverage would naturally translate into optimal care pathways. However, this study suggests that this assumption holds tenuous validity in contexts of high spatial and racial fragmentation. First, the racial convergence in hospice facility utilization without a synchronous decline in acute care dependence suggests that improving "access" via market-based insurance tools is insufficient to alter entrenched pathways of institutional reliance. In areas lacking community-based pain management infrastructure, emergency and inpatient care continue to serve as the de facto providers of end-of-life support. Second, the identification of "Hospice Deserts" indicates that inequality is largely a result of spatial supply insufficiency rather than individual choice. Without simultaneous investment in local care capacity, de-institutionalization policies risk displacing high-risk populations from institutions into unsupported community environments. Thus, future policy must shift focus from solely demand-side insurance coverage to the systemic construction of supply-side community care capacity. This does not negate the role of insurance expansion but

highlights that its efficacy is contingent upon local infrastructure. Utilizing geospatial data to identify zones where high burden overlaps with low resources—and prioritizing the deployment of pain management and hospice services in these areas—may be more effective than insurance expansion alone in mitigating structural inequalities. We advocate for the establishment of "Pain Management Enterprise Zones" to target these deep-seated disparities.

4.5 Strengths and Limitations

This study is distinguished by its theoretical depth, methodological rigor, and extensive temporal scope. First, regarding methodological innovation and data recovery, we addressed the widespread "data suppression" in CDC mortality records for minority and rural populations by developing a validated Truncated Poisson Monte Carlo Simulation method. By probabilistically reconstructing suppressed count information while adhering to official release rules, this approach significantly enhanced the statistical power for marginalized groups and reduced structural bias caused by missing data. Second, we provide a structural explanation that transcends traditional SES frameworks. By integrating geospatial variables and insurance market penetration, our multivariate models confirm that race remains robustly associated with the place of death even after controlling for income and rural-urban status, supporting the premise that "racialized geography" acts as an independent structural exposure. Finally, the long-term longitudinal perspective spanning 1999–2020 allows us to situate shifts in end-of-life care within a broader institutional history—capturing the opioid crisis and healthcare reform—thereby identifying structural inertia, such as path-dependent "institutional retention," which short-term cross-sectional studies might overlook.

Several limitations **w**arrant consideration when interpreting these findings. First, we acknowledge the heterogeneity of home death outcomes. Due to data structure limitations, we could not distinguish between supported home hospice care and unsupported home death within Tier 3. Given evidence that Black patients often face disadvantages in community pain management resources, we conceptualized Tier 3 as a potential "structural risk space" rather than a definitive measure of quality. Second, inferences are limited by the ecological nature of the analysis. As findings regarding Medicare Advantage penetration are based on county-level aggregates, they reflect structural associations at the population level and should not be extrapolated as individual-level causal effects, given that Black patients in high-MA areas may not personally be enrolled in these plans. Finally, the lack of clinical granularity in the CDC WONDER database (e.g., absence of Gleason scores or pain assessments) means we cannot fully rule out the role of clinical heterogeneity, although advanced prostate cancer generally entails a uniformly high symptom burden. Future research integrating clinical registries with spatial data is needed to further disentangle clinical demand from structural supply.

Overall, this study does not seek to explain complex racial disparities through a single mechanism; rather, it reveals how end-of-life care risks are redistributed amidst the intersection of de-institutionalization, insurance expansion, and spatial inequality. Even in contexts of improved insurance

coverage, spatial structures lacking community-based care and pain management infrastructure may continue to shape unequal end-of-life pathways.

Conclusion

Through an exhaustive analysis of 20 years of nationwide data, this study confirms that the "Racialized Geography" of prostate cancer hospice care has not naturally dissolved over time. While the expansion of Medicare Advantage successfully narrowed the racial gap in accessing high-quality hospice facilities, this market mechanism failed to touch the structural roots deeply embedded in geographic segregation, leaving Black patients disproportionately "trapped" in the acute care system. True medical equity cannot stop at an insurance card. It demands that we confront the spatial reality of "Hospice Deserts" and implement place-based targeted interventions, such as "Pain Management Enterprise Zones." Only then can we provide every life—regardless of race or zip code—with the fundamental right to freedom from pain at the end of life.

Declarations

Ethics approval and consent to participate

The study was conducted in accordance with the Declaration of Helsinki. The Ethics Committee of Jiading District Central Hospital Affiliated Shanghai University of Medicine & Health Sciences waived the requirement for ethical approval and informed consent, as the study utilized exclusively publicly available, de-identified aggregate data from the Centers for Disease Control and Prevention (CDC) WONDER database.

Consent for publication

Not applicable.

Availability of data and materials

The raw mortality data analyzed during the current study are available in the CDC WONDER Multiple Cause of Death database repository, [https://wonder.cdc.gov/mcd.html]. The processed datasets generated and analyzed during the current study are included in this published article and its additional files.

Competing interests

The authors declare that they have no competing interests.

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decision to publish, or preparation of the manuscript.

Authors' contributions

JY and QF conceived and designed the study. JY was responsible for methodology, software, formal analysis, investigation, data curation, and visualization. QF provided resources, supervision, and project administration. JY wrote the original draft. QF and JY reviewed and edited the manuscript. All authors read and approved the final manuscript.

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Table 1

Table 1 is available in the Supplementary Files section.

Figures

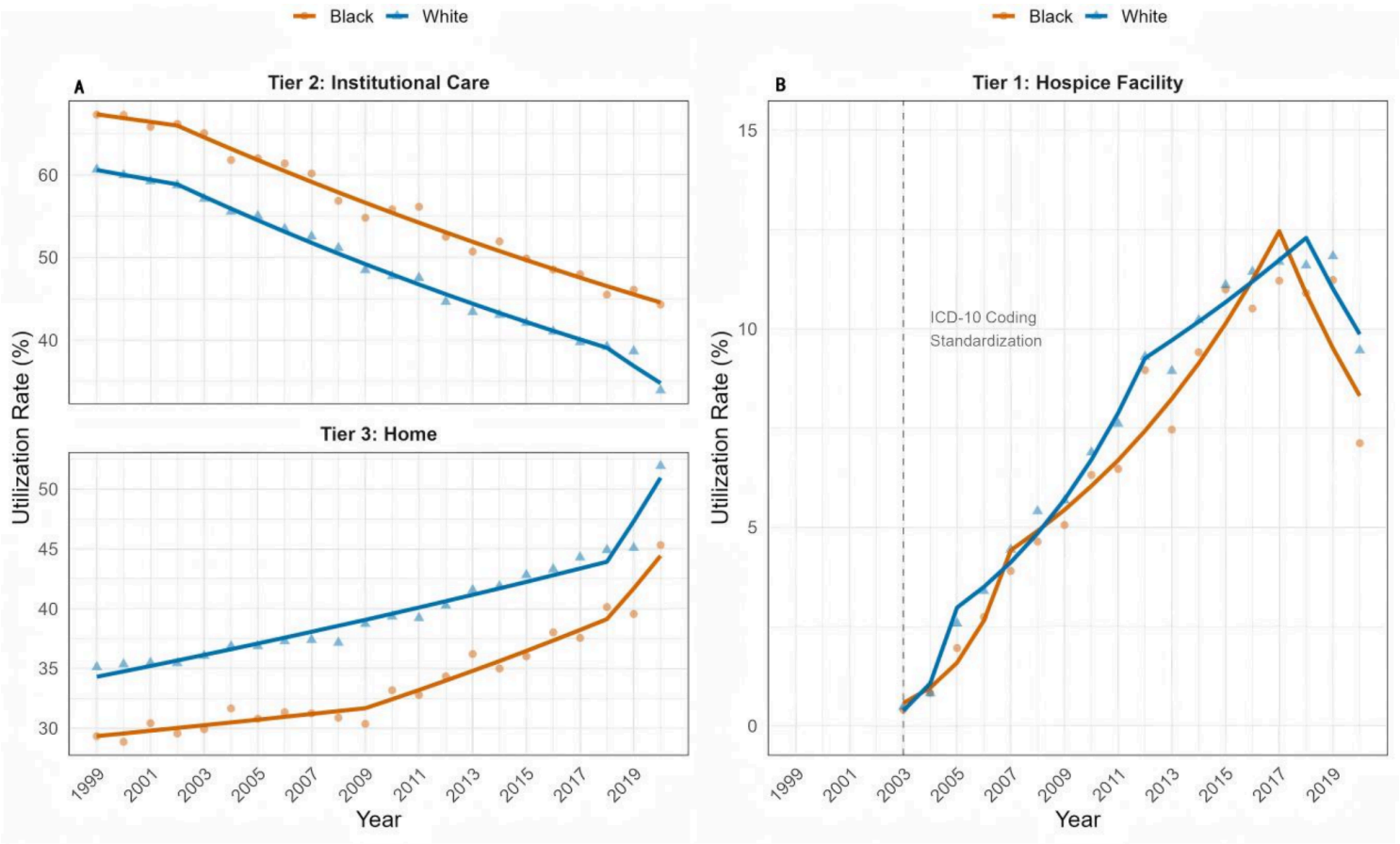


Figure 1

Temporal Trends in End-of-Life Care Utilization for Prostate Cancer Decedents by Race, 1999-2020. A. Trends in Reactive & Unsupported Care (1999-2020). B.Trends in Proactive Hospice Care (2003-2020).

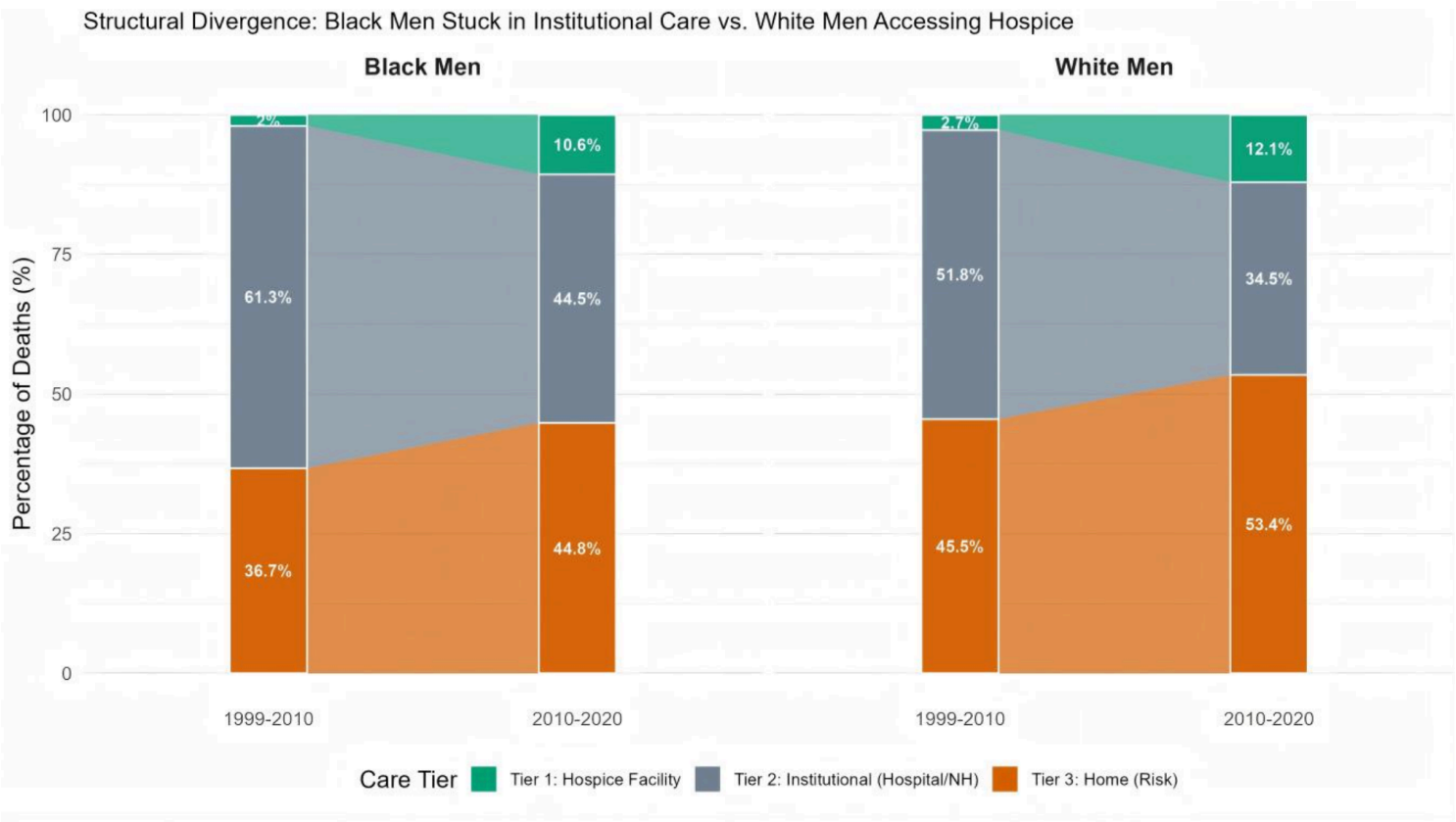


Figure 2

Ecological Shifts in Place of Death (1999-2020).

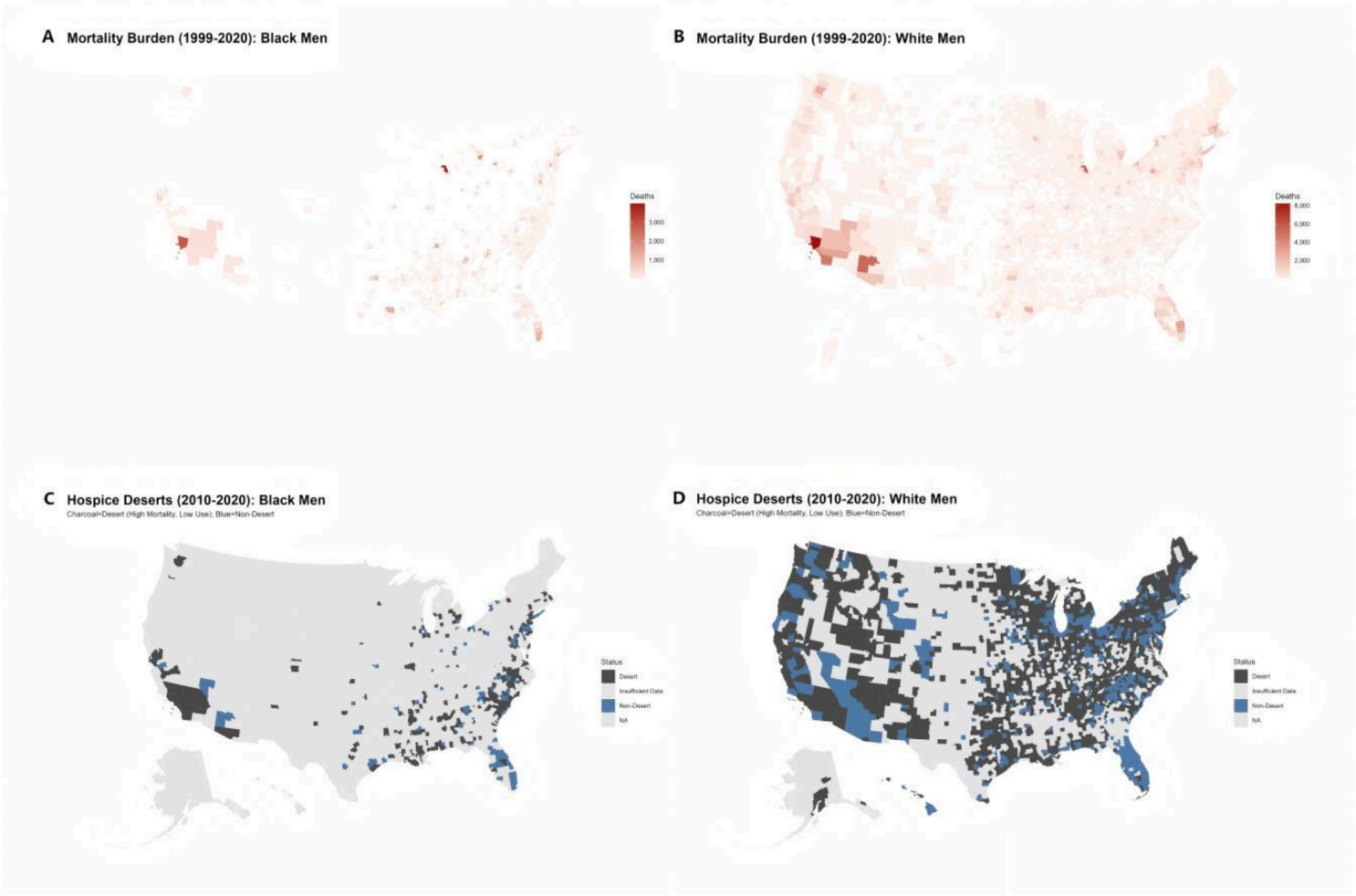


Figure 3

Ecological Transition of Place of Death, 1999-2020: Racialized Structural Lag.

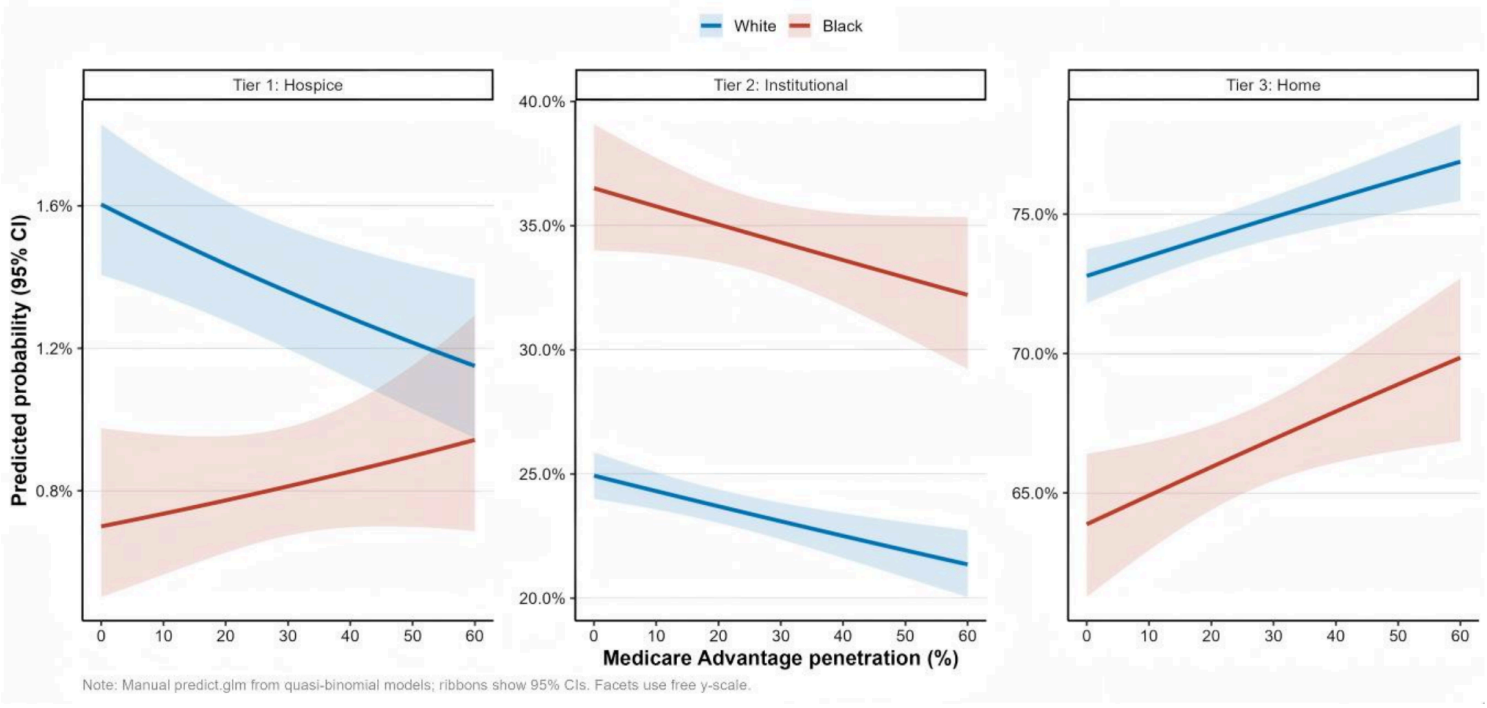


Figure 4

Predicted probabilities across care settings.

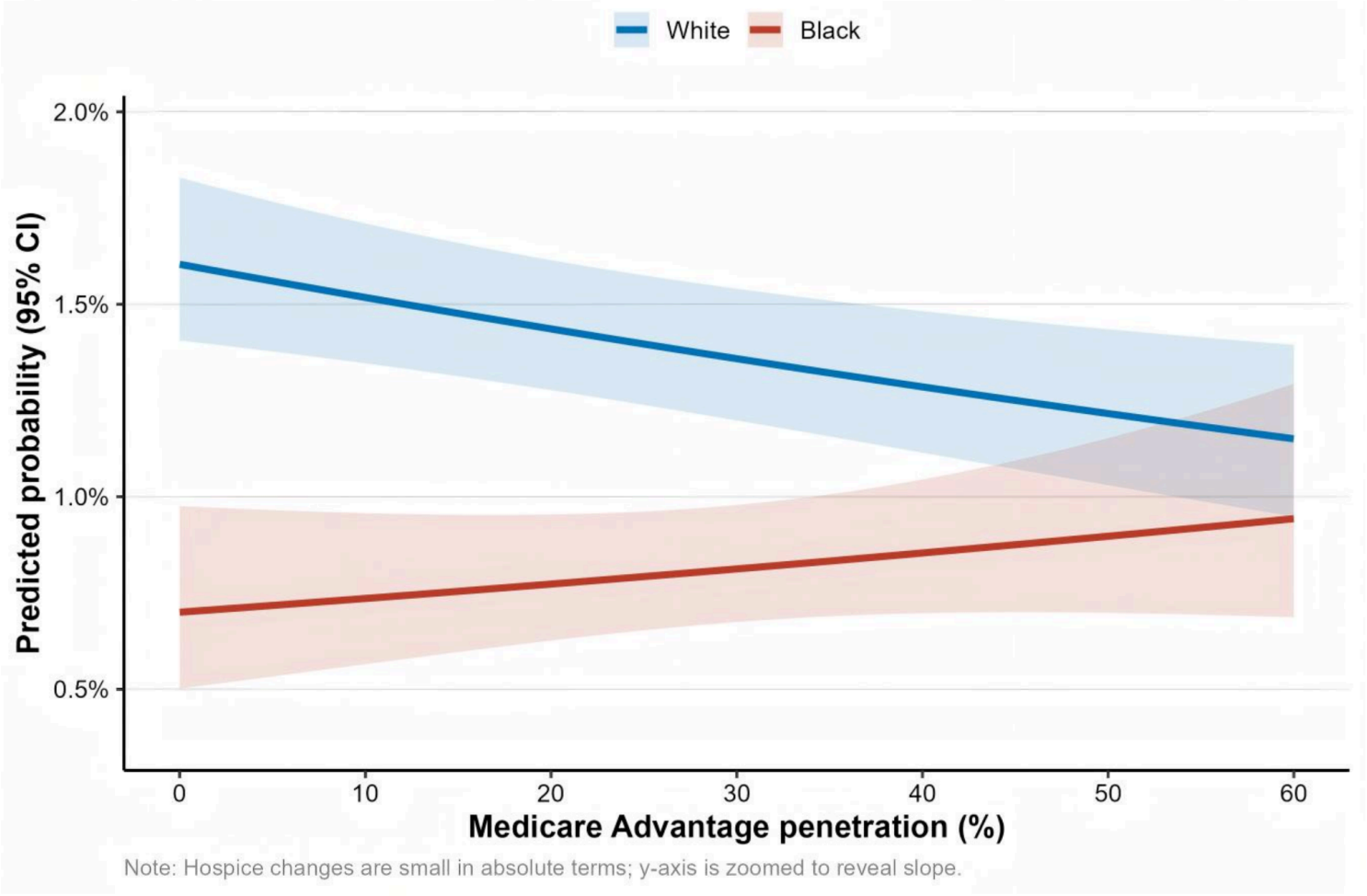


Figure 5

Zoom-in: Hospice (Tier 1).

Supplementary Files

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

- SupplementaryMaterial1.doc
- SupplementaryMaterial2.doc
- Table1.doc