# The Epidemiology of Pulmonary Embolism: Racial Contrasts in Incidence and In-Hospital Case Fatality

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This research was exempted from review by the institutional review board of Rutgers, The State University of New Jersey because it used only secondary, anonymous data sets.

Mortality from pulmonary embolism (PE) has declined in the United States over the past two decades, yet significant racial disparities persist with the age-adjusted rates for blacks about twice those for whites. Incidence studies to date have not been successful in defining reasons for this disparity, primarily because they have not enrolled sufficient numbers of blacks to allow for racial comparisons. This study overcomes that limitation by using New Jersey hospital discharge data as a surrogate measure for PE incidence. It examines whether differences in access to care, in-hospital case fatality, discharge planning or other factors might help explain the observed patterns. Our results revealed an elevation in the incidence of PE among blacks compared with whites, similar to the contrasts in mortality. In-hospital case fatality did not differ notably between blacks and whites, indicating that treatment in-hospital is an unlikely contributing factor. We found differences in hospital discharge planning and insurance status, suggesting that these factors may play a role. Our results point to the need for longitudinal studies on the natural history of the disease to better identify and hopefully modify the risk factors responsible for the persistent disparity in mortality from PE.

**Key words:** epidemiology ■ pulmonary embolism ■ racial disparities

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Considerable progress has been made in the prevention and treatment of pulmonary embolism (PE), resulting in a substantial decline in mortality from the disease in the United States. From 1979–1998, the annual age-adjusted mortality from PE declined from 45 to 33 deaths per million persons.[1] Despite this decline, significant disparities in mortality from PE persist, with the 1998 age-adjusted rates for blacks about twice those for whites (6.9 and 3.2 per 100,000 for black and white men; 5.9 and 3.0 for black and white women, respectively).[1]

The persistent racial disparity in PE mortality may reflect contrasts in disease incidence, case fatality/survivorship or both. Stein et al. found PE case fatality higher for blacks than for whites and a significant association between case fatality and increasing age.[2] The researchers did not, however, age adjust their case fatality rates, leaving open the question of confounding by age. Two population-based studies on PE incidence in the United States focused on predominantly rural populations,[3,4] but they had insufficient numbers of black subjects to afford race-specific comparisons of incidence rates. White and colleagues examined the role of race, ethnicity and gender on PE in California and found differences in case fatality by all three factors.[5] Whether these differences are state specific and whether these variables are surrogates for access to care has not been established.

New Jersey is a highly urbanized state, with large numbers of ethnic and racial minorities. The Census Bureau reported >2.1 million black New Jersey residents in 2000 (14% of the state's population).[6] Therefore, New Jersey provides a sufficiently large and diverse population for examining racial contrasts in PE incidence and mortality, one that might provide useful insights regarding the disparities seen in the mortality data. In this paper, we report the results of a probative effort to find explanations for the black–white disparity in PE mortality.

## DATA AND METHODS

### Mortality

To determine whether New Jersey's experience with PE mortality is similar to that for the nation as a whole, we selected the National Center for Health Statistics Compressed Mortality File as our data source. After 1998, mortality coding in the United States shifted to

ICD-10, whereas for clinical and administrative data sets it remained at ICD-9. In order to be certain that the coding change would not impact our analysis, we selected all PE deaths in the United States for the years 1989–1998, the most recent decade of data available online at CDC Wonder[1] using the ICD-9 coding scheme (code 415.1).

Average annual age-specific PE mortality rates were calculated for the United States by race and gender and the corresponding standard errors estimated using the method of Chiang.[7] Age-adjusted rates and standard errors were then calculated for each race-gender combination using the 2000 U.S. population as the standard. The respective rates were then examined for statistically significant differences as per the comparative method described by Fleiss.[8]

We subset the data set by restricting it to New Jersey deaths only and repeated the analysis. We also split the data into two equal time periods to account for the decline in PE mortality from 1989–1998[9] and repeated the analysis for both the national and New Jersey data sets. The respective age-specific and age-adjusted rates for each race/gender combination were once again compared for significant differences.[8]

## Incidence

We selected anonymous New Jersey uniform billing data (UB-92) as our data source for evaluating the incidence of PE in New Jersey. One limitation of using discharge data is that it is designed for administrative use rather than for epidemiology and does not contain many of the variables we would like to explore as risk factors for PE. Another is that it also does not contain those cases that die outside the influence of a hospital, such as at home or in a nursing facility. We believe, however, that persons who suffer a PE are likely to seek medical care and will probably experience hospital admission. We could find no evidence that hospitalized patients are subject to a selective diagnosis of PE based upon race. Thus, if even a large number of cases of PE go undiagnosed (i.e., the data lack sensitivity),[10] the data set is most likely unbiased.

A positive feature of using discharge data is that cases that expire in transit to the hospital or in the emergency room are included in the data set. In other words, while discharge data may not capture 100% of incident cases, we believe it is a good surrogate for overall PE incidence as the data set is population based, provides case-level data and uses the same coding system as our mortality data set (ICD-9 code 415.1). We selected the three most recent years of data available (1998–2000) in order to ensure sufficient numbers of cases for examining racial contrasts.

As New Jersey is located between New York City and Philadelphia, we were concerned that out-of-state

**Table 1. Age-adjusted death rates* per million, with standard errors and numbers of cases, for pulmonary embolism in the United States and New Jersey, 1989–1998, by race and gender**

| Gender | Race | Location | AAR | SE | N |
|---|---|---|---|---|---|
| Male | White | NJ | 35.2 | 1.2 | 994 |
| | White | US | 37.2 | 0.2 | 33,124 |
| | Black | NJ | 65.6 | 5.0 | 216 |
| | Black | US | 78.0 | 1.0 | 7,076 |
| Female | White | NJ | 30.3 | 0.9 | 1,291 |
| | White | US | 32.2 | 0.2 | 41,773 |
| | Black | NJ | 66.5 | 4.0 | 297 |
| | Black | US | 64.4 | 0.7 | 8,578 |

Source: National Center for Health Statistics Compressed Mortality File; * U.S. 2000 standard; AAR: age-adjusted rate; SE: standard error

**Table 2. Age-adjusted death rates* per million, with standard errors and numbers of cases, for pulmonary embolism in the United States and New Jersey, 1989–1993 and 1994–1998, by race and gender**

| | | | 1989–1993 | | | 1994–1998 | | |
|---|---|---|---|---|---|---|---|---|
| Gender | Race | Location | AAR | SE | N | AAR | SE | N |
| Male | White | NJ | 39.0 | 1.8 | 528 | 31.8 | 1.5 | 466 |
| | White | US | 40.9 | 0.3 | 17,335 | 33.8 | 0.3 | 15,789 |
| | Black | NJ | 74.6 | 8.1 | 111 | 58.2 | 6.2 | 105 |
| | Black | US | 85.1 | 1.5 | 3,625 | 71.7 | 1.3 | 3,451 |
| Female | White | NJ | 31.7 | 1.2 | 661 | 29.0 | 1.2 | 630 |
| | White | US | 33.9 | 0.2 | 21,226 | 30.6 | 0.2 | 20,547 |
| | Black | NJ | 67.0 | 5.8 | 141 | 65.7 | 5.4 | 156 |
| | Black | US | 68.6 | 1.1 | 4,313 | 60.6 | 0.9 | 4,265 |

Source: National Center for Health Statistics Compressed Mortality File; * U.S. 2000 standard; AAR: age-adjusted rate; SE: standard error

migration for healthcare might bias our results. To test that hypothesis, we obtained UB-92 data for New York and Pennsylvania for the same time period and compared the numbers of out-of-state residents treated at hospitals in the respective states.

We were also concerned that a primary rather than any discharge diagnosis of PE might bias our results. To test that hypothesis, we calculated age-adjusted incidence rates for both diagnostic fields and compared the results. Finally, data were stratified by race, gender and age group, and compared for vital status at discharge, place of disposition at discharge, and insurance status using z tests of proportions. By examining these variables, we hoped to gain insight into whether there are systematic differences in the way racial groups gain access to treatments and discharge options upon hospitalization for PE.

# RESULTS

## Mortality

The age-adjusted death rates for PE in the United States and for New Jersey residents by race and gender (1989–1998) are shown in Table 1. The rates for New Jersey were similar to those for the United States as a whole, except for black men. For black men, the rate was lower in New Jersey compared to that for the United States as a whole; however, the general pattern of mortality was not greatly affected by this difference. For both genders, mortality among New Jersey blacks was greater than among New Jersey whites ($p<0.01$), thus demonstrating the racial contrasts in PE mortality demonstrated in the national data set.

Age-adjusted PE mortality rates for both the United States and New Jersey for the periods 1989–1993 and 1994–1998 (Table 2) show declines in mortality from the earlier period to the later one for all race-gender groups. Within each time period and for both races, mortality was significantly higher for blacks than for whites ($p<0.001$) and for men compared to women ($p<0.01$). While PE mortality declined between time periods, the racial contrast remained strong, with blacks at a significant disadvantage.

## Incidence

**Impact of migration.** The total number of New Jersey residents treated in New York and Pennsylvania hospitals for either a primary or any diagnosis of PE were 333 and 759, respectively. Similarly, out-of-state residents treated for PE in New Jersey hospitals for a primary or any diagnosis of PE were 190 and 327, respectively. As the difference of 143 cases comprised only 2% of the primary diagnosis of PE data set (N=5,995) and as the difference of 432 cases comprised <4% of the any diagnosis of PE data set (N=10,542), we determined that migration did not significantly bias our results.

**Impact of diagnostic coding.** A comparison of the age-adjusted rates for each race/gender combination in the primary diagnosis of PE and any diagnosis of PE data sets yielded no statistically significant differences for any race/gender combination; all were within 1 SE (data not shown). Thus, we selected any diagnosis of PE in order for our remaining analyses to be inclusive and to provide additional statistical power.

**Racial and gender disparities.** Table 3 shows the 1998–2000 age-adjusted incidence rates per 100,000 by race and gender for PE as any diagnosis in the New Jersey hospital discharge data set. The age-adjusted PE

**Table 3. Age-adjusted hospital discharge diagnosis rates per 100,000* for any diagnosis of pulmonary embolism (ICD-9 rubric 415.1) in New Jersey hospital discharge summaries, 1998–2000, by gender and race**

| Population | AAR | SE | N | Black/White Rate Ratio |
|---|---|---|---|---|
| Total Males | 39.17 | 0.59 | 4,350 | |
| White | 36.47 | 0.62 | 3,464 | |
| Black | 53.64 | 2.15 | 621 | 1.47† |
| Total Females | 42.10 | 0.54 | 6,192 | |
| White | 37.96 | 0.55 | 4,812 | |
| Black | 61.53 | 1.98 | 961 | 1.62† |
| Total | 40.93 | 0.40 | 10,542 | |

Source: New Jersey Hospital Discharge Data (UB-92); * U.S. 2000 standard; † $p<0.001$; AAR: age-adjusted rate; SE: standard error

**Table 4. Vital status at hospital discharge for patients with any diagnosis of pulmonary embolism (ICD–9 rubric 415.1) in New Jersey hospital discharges, 1998–2000, by race and gender**

| | | Vital Status at Discharge | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Race | Gender | Alive | | Expired | | Miscode | | Total | |
| | | N | % | N | % | N | % | N | % |
| White | Male | 3,013 | 86.98 | 448 | 12.93 | 3 | 0.09 | 3,464 | 100 |
| | Female | 4,176 | 86.78 | 630 | 13.09 | 6 | 0.12 | 4,812 | 100 |
| Black | Male | 533 | 85.83 | 88 | 14.17 | 0 | 0.00 | 621 | 100 |
| | Female | 833 | 86.68 | 126 | 13.11 | 2 | 0.21 | 961 | 100 |

Source: New Jersey Hospital Discharge Data (UB-92)

incidence rates for females were higher than those for males for both races, an inverse pattern from the national mortality data where male death rates were higher. The table also shows that regardless of gender, age-adjusted PE incidence was significantly higher for blacks than for whites ($p<0.001$). Among males, the incidence of PE was 47% higher for blacks than for whites; for females it was 62% higher.

We examined the incidence data for vital status on discharge to determine if competing mortality could play a role in explaining the disparity in mortality rates. That is, we wanted to determine whether specific subgroups might be more likely to be discharged alive so that they might later succumb to a fatal outcome other than PE. Table 4 shows vital status at discharge for New Jersey patients with any diagnosis of PE by race and gender. Proportionally, about 13% of all patients expired in the hospital, and this did not vary significantly between any of the race-gender groups (range: 12.93–14.17%). Thus, in-hospital case fatality does not contribute to the higher PE mortality rates observed for blacks compared to whites. Once admitted, the chances of surviving the hospitalization from PE were not statistically different based on race.

We considered whether disposition at discharge for any diagnosis for PE was significantly different between groups and whether this might help explain differences in mortality rates. The data set included codes for disposition to a short-term hospital, a skilled nursing facility, intermediate care facility, another type of facility, home care with supervision, left against medical advice, home with intravenous medication, expected to return for outpatient services and expired/dead. Some of these are important as they would be places where PE mortality would not be captured by the UB-92 data set. We examined the disposition data first by race (Table 5). The table shows that blacks were somewhat more likely to leave the hospital against medical advice and more likely to expire compared to whites, but these differences were not statistically significant ($p=0.28$ and $p=-0.89$, respectively).

We then examined the disposition data by gender within racial categories to determine whether there were patterns that might help explain the racial contrasts (data not shown). For males, we found a slightly larger proportion of whites were discharged home under the supervision of a home healthcare organization than were blacks, although this difference was not significant ($p=0.91$). Black males were somewhat more likely to leave against medical advice than were white males, but this difference was also not significantly different ($p=0.28$). White females were somewhat more likely to be discharged to a skilled nursing facility than were black females, but the differences were not significant ($p=0.54$). White females were also somewhat more likely to be discharged to another type of facility or home under supervision of a home healthcare organization that were black females, but, again, these differences were not statistically significant ($p=0.86$ and 0.93, respectively). Overall, patterns in disposition after a diagnosis of PE differed somewhat, but they did significantly explain the strong racial contrasts in PE mortality.

To determine whether insurance coverage might play a role, perhaps in terms of access to primary, emergency or follow-up care, we examined the incidence data for payer information. Table 6 shows the information on third-party payer status for patients with any diagnosis of PE by race. Blacks were somewhat more likely to be covered by Medicaid than whites ($p=0.096$), and whites were significantly more likely to be covered by Medicare than blacks ($p<0.001$). The difference in self-pay/charity care/underinsured was also significantly

**Table 5. Detailed disposition at hospital discharge for any diagnosis of pulmonary embolism (ICD–9 rubric 415.1) in New Jersey hospital discharges, 1998–2000, by race**

| | White | | Black | |
|---|---|---|---|---|
| **Disposition** | **N** | **%** | **N** | **%** |
| Discharged | | | | |
| Home | 4,552 | 55.00 | 930 | 58.79 |
| Short-term hospital | 234 | 2.83 | 38 | 2.40 |
| Skilled nursing facility | 984 | 11.89 | 157 | 9.92 |
| Intermediate care facility | 51 | 0.62 | 17 | 1.07 |
| Another type of facility | 494 | 5.97 | 73 | 4.61 |
| Home care under supervision | 826 | 9.98 | 130 | 8.22 |
| Left facility against medical advice | 32 | 0.39 | 19 | 1.20 |
| Home on IV medications | 16 | 0.19 | 1 | 0.06 |
| Patient expected to return as outpatient | 0 | 0.00 | 1 | 0.06 |
| Expired/Died | 1,078 | 13.03 | 214 | 13.53 |
| Unknown | 9 | 0.11 | 2 | 0.13 |
| Total | 8,276 | 100 | 1582 | 100 |

Source: New Jersey Hospital Discharge Data (UB-92)

different between the racial groups, with blacks having a higher proportion of cases compared to whites (p=0.023). When the data were examined by gender and race, these patterns held (data not shown).

## DISCUSSION

We found PE mortality rates in New Jersey similar to those for the United States as a whole, with rates for blacks significantly higher than for whites. Age-specific mortality for both races and genders increased with ascending age. Age-adjusted mortality rates for PE declined from 1989–1993 to 1994–1998 with the rates in both periods significantly greater among blacks than among whites. Our examination of discharge data as a surrogate for PE incidence among New Jersey residents showed women at greater risk of hospitalization for PE than men, with black rates for both genders significantly elevated compared to comparable white rates. We found no significant differences for in-hospital case fatality, nor did we find that disposition of cases differed significantly by race or gender group.

This study has limitations related to the selection of data sources. For example, mortality data may reflect errors in diagnosis, recording of data and processing, and thus may not accurately reflect the underlying risk of developing disease. It may also convolute incidence and case fatality. Despite these limitations, we found concordance in PE mortality between the United States and New Jersey data sets, a result suggesting that incidence patterns for PE may also be similar between the two.

As there is no national data set on PE incidence and as PE mortality was similar in both the United States and New Jersey data sets, we believe that probing the disparity using data on the New Jersey population is a valid methodology. Hospital discharge data represent proxy information regarding the incidence and prevalence of PE in the community. It is an imperfect data set as some individuals suffering a PE may never reach the hospital and others may be hospitalized numerous times, each instance of which may or may not be related to PE. While we had case-level data, we did not have the ability to track multiple admissions for individuals. We attempted to control for a primary hospitalization for PE versus one in which the patient's past history or in-hospital experience played a role (any diagnosis of PE on the discharge summary). Although the rates for the former were not surprisingly lower than for the latter, the demographic contrasts were the same.

Both the mortality and discharge data sets are likely subject to underreporting of cases. Indeed, Skaf et al. report the sensitivity of death certificates for identifying fatal PE between 27–37%.[10] We do not believe this is not a serious limitation for this study, however, as there is no evidence that PE is underdiagnosed selectively—that is, that the disparity in PE mortality is explained by underdiagnosis in one racial group relative to another. In other words, any underreporting of PE cases in these population-based data sets is unlikely to be racially biased.

We tested whether migration might have biased our results. As only 2–4% of patients with a diagnosis of a PE left the state for treatment, migration had little impact.

Overall, our results show that women experienced a higher incidence of hospitalization for PE compared to men, regardless of race. We also found that blacks experienced an elevated risk of developing PE compared to whites, regardless of gender. In-hospital case fatality did not differ significantly between racial groups and, while there were some differences in discharge planning, these were not statistically significant.

**Table 6. Payer information for hospitalized cases for any diagnosis of pulmonary embolism (ICD-9 rubric 415.1) in New Jersey hospital discharges, 1998–2000, by race**

| Payer | Race | | | | |
|---|---|---|---|---|---|
| | White | | Black | | Total |
| | N | % | N | % | N |
| CHAMPUS | 5 | 0.06 | 6 | 0.38 | 12 |
| Commercial insurance | 527 | 6.37 | 91 | 5.75 | 665 |
| Commercial PPO | 34 | 0.41 | 6 | 0.38 | 44 |
| HMO/prepaid/BlueCross | 1,869 | 22.58 | 360 | 22.76 | 2,392 |
| Medicaid | 140 | 1.69 | 105 | 6.64 | 279 |
| Medicare | 4,512 | 54.52 | 700 | 44.25 | 5,513 |
| N.J. BlueCross | 662 | 8.00 | 122 | 7.71 | 841 |
| Other | 102 | 1.23 | 19 | 1.20 | 133 |
| Other BlueCross | 146 | 1.76 | 24 | 1.52 | 181 |
| Other government | 18 | 0.22 | 8 | 0.51 | 26 |
| Self-pay charity/underinsured | 216 | 2.61 | 136 | 8.60 | 404 |
| Workers' compensation | 45 | 0.54 | 5 | 0.32 | 52 |
| Totals | 8,276 | 100 | 1,582 | 100 | 10,542 |

Source: New Jersey Hospital Discharge Data (UB-92)

Our findings show that the racial disparity in mortality from PE is largely accounted for by differences in the incidence of the disease, with blacks at significantly higher risk. We also note that insurance status may partly explain this disparity. Specifically, we found that blacks with a discharge diagnosis of PE were more likely to be poor (underinsured, on Medicaid) compared to their white counterparts. It follows that additional cases of PE may exist among the poor and uninsured, and that these cases were not identified because some uninsured individuals may not seek care, even in cases of extremis, or they may suffer a sudden fatal incident and never enter a transport system to a hospital. Thus, our results likely underestimate the total incidence of PE, especially among the poor, many of whom are likely to be black. In other words, our findings are conservative and the true difference in PE incidence between racial groups may be even stronger.

When individuals do not enter the medical system, analyses from existing studies, such as the Prospective Investigation of Pulmonary Embolism Diagnosis (PIOPED), will not provide insight into the postdischarge experience among those sustaining a PE.[11] Such studies are also limited by their ability to provide information on the primary risk factors for developing the disease. Rather, we need population-based natural history observational studies in which cohorts are recruited and followed to identify which factors are responsible for differences in disease incidence.[12,13] Such studies must take place in populations with considerable numbers of both blacks and whites and must include individuals across the socioeconomic spectrum. From the knowledge gained in such investigations, preventive approaches may be developed that will help clinicians and their patients develop population-based strategies to reduce mortality associated with PE.

## CONCLUSION

Mortality from PE in the United States and in New Jersey during 1989–1998 followed similar demographic patterns, with blacks experiencing excess mortality compared with whites. This study examined PE mortality by using hospital discharge data from 1998–2000 as a surrogate for PE incidence. We found in-hospital case-fatality similar between races, suggesting that the contrast in mortality is independent of the hospital experience, i.e., the disparity occurs either prior to entering the hospital system or postdischarge. We also found the incidence of PE among blacks increased compared to whites and that the lack of insurance coverage and increased underinsured status among blacks explains some of the disparity. Reasons for the increased incidence of PE among blacks remain to be explored as the variable is nonspecific, usually obtained by individuals self-identifying into imperfect categories that may not be reflective of risk.[14] In other words, the variable does not necessarily reflect access to care, socioeconomic status, family history, diet and nutrition, or a host of other factors. To overcome this limitation, population-based natural history observational studies are needed to provide information that will allow researchers to further address this demographic contrast.

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