Ischemic Heart Disease and Hypertension: Effect of Disease Coding on Epidemiologic Assessment

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Synopsis ....

During the changeover from the eighth to the ninth revision of the "International Classification of Diseases: Manual of the International Statistical Classification of Diseases, Injuries, and Causes of Death" (ICD), there were several major alterations of coding for the rubrics Ischemic Heart Disease (IHD) and Hypertension (HBP). As expected, these changes caused major discontinuities for IHD and HPB. These discontinuities were not, however, uniform over sex-race groups. When examined by component ICD codes, the discontinuities were found to vary in both magnitude and direction among the groups. In addition to discontinuity, there was a change in the rate of decline for IHD and HBP after the changeover. This rate of decline varied as well by sex-race group. In general, the decline among blacks was slower than among whites.

Earlier studies that assessed IHD mortality have used different groupings of ICD codes to obviate the discontinuity, and researchers have observed a similar differential decline. These results should be viewed with caution because of the potential impact of differential coding on sex-race groups. As preparations are made for ICD-10, special attention should be given to the preservation of epidemiologic continuity to provide better assessment of trends in population subgroups.

THE NINTH REVISION of the International Classification of Diseases (1) replaced the eighth revision (2) in the United States in 1979. It was well recognized that the ninth revision, like its predecessors, produced a number of changes: shifts of disease rubrics, regroupings, introduction of new titles, and modification of coding rules. Some of the changes had trivial impact; others created serious breaks in comparability and continuity. Several large studies examined the effect of the changeover on mortality data (3) and hospital discharge data (4) and produced sets of comparability ratios—the number of cases in a sample that are classified to a particular ICD code grouping using the ninth revision (ICD-9) compared with the number so classified using the eighth revision (ICD-8).

Comparability ratios are calculated without regard to specific characteristics of decedents. It is not known a priori whether changes in coding will have a differential impact on subgroups of the population. In this article, we explore the effect of the shift from ICD-8 to ICD-9 on ischemic heart disease (IHD) and hypertension (HBP). We examine these diagnostic categories, as defined in the classification manuals (1,2) and their component ICD codes in order to describe the differential impact on four sex-race groups in the population: black women, black men, white women, and white men.

Methods

We used the multiple-cause-of-death mortality tapes prepared by the National Center for Health Statistics for the years 1968 to 1986 (5). All cases were included that contained a mention of any of ICD codes 400 to 405 or 410 to 414 anywhere on the record. These codes were used individually and in the reconstruction of the rubrics IHD and HBP for ICD-8 (1968-78) and ICD-9 (1979-86) (table 1). All rates were age-adjusted using the 1980 total U.S. population as the standard.

We assessed the differential effect of the coding changeover by examining the ratio of the rates in 1979 to the rates in 1978, the difference between the rates in 1979 and the rates in 1978, and the ratio of the slopes during the period 1979-86 to the

Table 1. Component International Classification of Disease (ICD) codes and comparability ratios for the rubrics Ischemic Heart Disease (IHD) and Hypertension (HBP) in revision 8 (ICD–8) and revision 9 (ICD–9)

Rubric	ICD–8	ICD–9	Comparability ratios[1]
HPD	400–404	401–405	
Essential hypertension	400–401	401	0.84
Hypertensive heart disease...	402–404	402–404	0.45
IHD	410–413	410–414	
Acute myocardial infarction	410	410	1.03
Chronic IHD	412	412,414	1.42
Other IHD	411, 413–414	411,413	0.92
Other acute and subacute IHD	411	411	1.17
Angina pectoris	413	413	0.66

[1] The comparability ratio was obtained by coding a set of records under the rules for ICD–8 and ICD–9. For a given ICD code or group of codes, it represents the results for ICD–8 divided by the results for ICD–9. In a major comparability study (4), the overall ratios for the IHD and HBP rubrics were not given.

> There has been a general decline in the age-adjusted rate for ischemic heart disease and hypertension since 1968. This decline is apparent in all four sex-race groups for both rubrics, but it has not occurred uniformly in the four groups.

slopes during the period 1968–78. We used the two rubrics (IHD and HBP) and 8 of the 11 ICD individual codes. ICD–400 (present in ICD–8, absent in ICD–9), ICD–414 (absent in ICD–8, present in ICD–9), and ICD–405 ("empty" in both) were omitted from some portions of the analysis. In addition to the total population, we assessed four sex-race subgroups (black female, black male, white female, white male), which permitted examination of rate ratios, rate differences, and slope ratios for blacks compared with whites.

Since the rate ratios and rate differences were derived from the total population of deaths, no suitable estimates of their variances are available and significant testing of comparisons was not performed. Slopes were calculated using ordinary least squares linear regression. We tested the null hypothesis of no difference between slopes with a *t*-test (the difference divided by the square root of the sum of the variances). For clarity, we expressed the slopes as ratios.

Results

There has been a general decline in the age-adjusted rate for IHD and HBP since 1968 (fig. 1). This decline is apparent in all four sex-race groups for both rubrics, but it has not occurred uniformly in the four groups (figs. 2 and 3). The rate of decline for IHD and HPB changed after 1979, but this change, as well, was not uniform in the four groups.

Ratio of the rates in 1979 to the rates in 1978. The rate ratio for IHD (1979 compared with 1978) was 0.83, indicating an overall fall of 17 percent in the age-adjusted rate for IHD (table 2). This ratio is a weighted average of the changes in individual ICD codes, whose rate ratios ranged from 0.03 (ICD–412) to 0.97 (ICD–413). The rate ratio for IHD is, at the same time, a weighted average of the rate ratios in the sex-race subgroups. On this axis, variability is considerably smaller (from 0.73 in black women to 0.85 in white men). For individual ICD codes, however, the range was greater: the rate ratios for acute myocardial infarction (ICD–410) differed by only 4 percent, but the rate ratios for angina pectoris (ICD–413) differed by 19 percent.

In contrast to IHD, there was a substantial rise in HBP, with an overall rate ratio of 4.00 for 1979 compared with 1978 (table 3). There was, however, variability similar to that for IHD in the rate ratios for the individual ICD codes, and the changes in ICD codes did not affect sex-race groups uniformly. For example, in the category of essential hypertension (ICD–401), the rate for white men increased by a factor of 9.12, but the rate in black men increased by a factor of only 7.45. The changes in black women compared with white women were parallel.

Differences between rates in 1979 and 1978. The overall differences observed in IHD (– 75 per 100,000) and HBP (+ 43 per 100,000) are linear combinations of the differences observed for their component ICD codes (table 3). The decline in IHD rate was larger for black men than for white men on both an absolute and proportional basis; the decline was – 116 per 100,000 in black men (a 25 percent decrease) compared with – 93 per 100,000 in white men (a 15 percent decrease).

The increase in HBP was also greater in black men than in white men (+ 80 versus + 43). Similarly, black women experienced a greater decline in IHD than did white women (– 83 versus – 57) and

a greater increase in HBP (+72 versus +35). It is apparent that none of the groups changed by similar amounts, and this is evident for changes within some individual ICD codes as well.

Ratio and difference of rates in blacks compared with whites. The differential changes displayed in tables 2 and 3 are reflected in the more direct comparisons of blacks with whites (table 4). For IHD in men, the black to white rate ratio was smaller in 1979 than in 1978. In 1979, the age-adjusted IHD rate in white men was 523 per 100,000; in black men, it was 343 per 100,000. The black to white ratio was 0.66. In 1978, the corresponding rates were 616 and 467, and the ratio was 0.75. The actual rates are not included in the tables, but can be read (approximately) from figure 1. Thus, the decline during the changeover was greater for black men than for white men. These relative changes are evident in the rate differences (table 4).

For HBP in men, the black to white rate ratio was also smaller in 1979 (1.97) than in 1978 (2.22), but for opposite reasons. For white men, the rate rose from 14 per 100,000 in 1978 to 56 per 100,000 in 1979. For black men, the rate rose from 31 per 100,000 to 111 per 100,000. The ratio declined, but the increase in rate was faster in blacks than in whites during the changeover. As displayed in table 4, the rate difference for men was 17 per 100,000 in 1978 and 54 in 1979.

The changes in women were identical in direction, but they began from different baselines and were smaller in magnitude. The absolute and relative differences between blacks and whites, men and women, are also reflected in the variability within individual ICD codes.

Ratio of slopes in 1979–86 compared with 1968–78. The decline in both IHD and HBP was less steep after the coding changeover than before. This change in slope was statistically significant for IHD but not for HBP (table 5). The ratio of slopes (1979–86 versus 1968–78) for IHD was 0.68, and reflected considerable diversity among the contributing ICD codes (from 0.03 for ICD–412 to 8.24 for ICD–413) and among the sex-race groups (from 0.44 in black women to 0.86 in white men).

Such diversity was also evident in the slope ratios for sex-race groups within individual ICD codes. The relative decline in acute myocardial infarction (ICD–410), for example, was considerably slower for black women after the coding changeover than it was for white men. For black women, the slope increased—that is, fell less rapidly—from −4.9

Figure 1. Trend in ischemic heart disease (IHD) and hypertension (HPB) in the United States, 1968–86, using the standard definition [1]
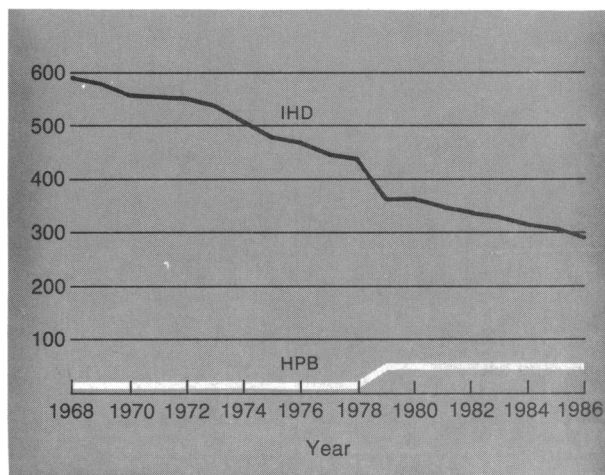

[1] References 1 and 2.

Figure 2. Trends in ischemic heart disease by sex-race group, United States, 1968–86
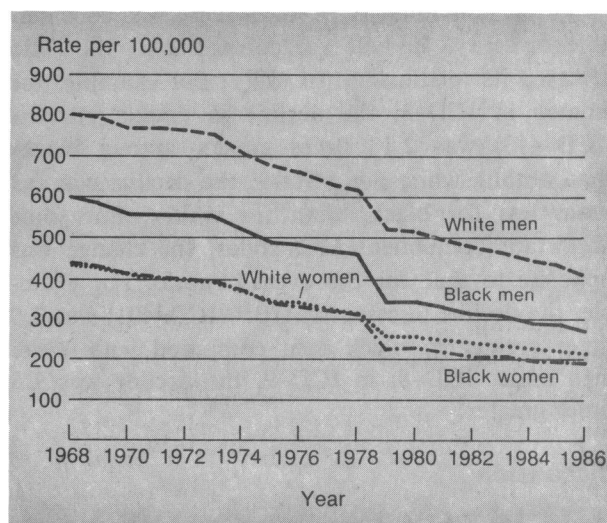
under ICD–8 to −1.8 under ICD–9, for a ratio of 0.38; for white men, it changed from −10.8 to −8.1, for a ratio of 0.75. Though the absolute changes are similar, the declines differ because of the differing starting levels.

As a result of the differential effect on slope ratios within sex-race groups, the ratio of the slopes for blacks versus whites declined after the changeover for both IHD and HBP. These changes were small for IHD—from 0.71 to 0.65 for men, and from 1.09 to 0.85 for women—but were substantial for HBP—from 2.21 to 1.17 for men; from 2.46 to 1.75 for women (table 6). This directly confirms the previous observation that,

Figure 3. Trends in hypertension by sex-race group, United States, 1968–86

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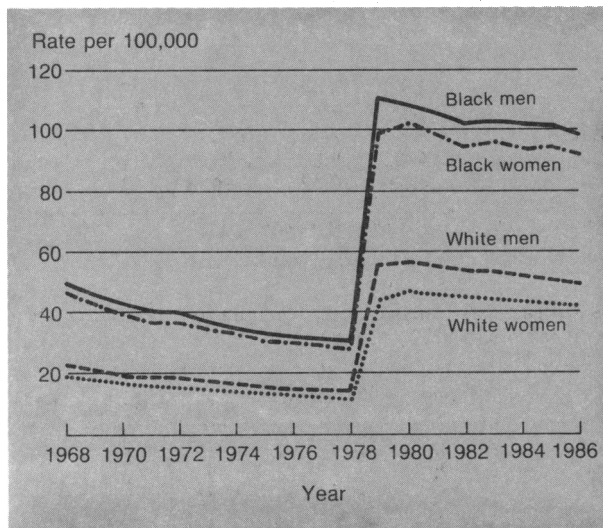
relative to whites, the rate of decline for blacks was slower after the changeover.

Within individual ICD codes there was considerable diversity. In half the comparisons, the ratio reversed its relationship to unity. For example, for women in ICD-8, the decline in angina pectoris (ICD-413) was 2.13 times greater among blacks than among whites; in ICD-9, the decline was 0.3 times less for blacks than for whites. For some important component ICD codes, the change was opposite to that for the overall rubric. For example, the decline in essential HBP (ICD-401) was 2.0 times greater in black men compared with white men under ICD-8; in ICD-9, the decline was 3.5 times greater.

Discussion

The periodic revision of ICD codes requires tradeoffs between diagnostic accuracy and epidemiologic continuity. In the ninth revision, for example, the attempt was made to provide better separation of chronic ischemic heart disease and hypertension by transferring large numbers of cases out of ICD-412 and into ICD-402 and ICD-401 (4). Though this provides a gain in precision, it "render(s) meaningless the comparison of estimates based on similarly titled codes" (4a). There is, nonetheless, the ongoing need to assess epidemiologic trends and make long-term comparisons which may span coding changes.

A major tool for assessing the impact of the coding changes is the comparability ratio, in use

since the earliest revisions (4). The comparability ratio provides a measure of how a diagnosis would have been coded before and after the changeover. It does not necessarily provide a direct measure for comparing age-adjusted rates. The results of this study should not be viewed, then, as an evaluation (or critique) of comparability ratios, but rather as an end results analysis. A number of factors affect trends in cause-of-death data (6), including underlying medical acumen, assiduousness of reporting, coding practices and procedures, as well as "true" underlying trends. The age-adjusted rate acts as a final common path, the net result of a variety of forces whose individual contributions may be difficult to identify.

This study documents the well-recognized changes in age-adjusted rate that occurred for IHD and HBP between 1978 and 1979 and highlights the diversity of these changes. It would not have been anticipated, prima facie, that the coding changeover would have had a differential effect on population subgroups, and that there would have been a variable impact on the trends for these subgroups.

In general, the age-adjusted rates for IHD in black men and women declined more than did the rates for whites between 1978 and 1979. Conversely, the increase in HBP was greater for blacks than for whites between the 2 years. The component ICD codes made differential contributions to these events, and these contributions were not uniform over the sex-race groups. The trend for both IHD and HBP was downward during both time intervals, but the rate of decline changed after 1979, and this change in decline varied within the sex-race groups. In general, the slopes after 1979 were significantly different, statistically, from the slopes for the period 1968–78, with some exceptions (tables 5 and 6). For IHD in black women, for example, the decline was considerably slower than for white men after 1979. For HBP in black men, the decline was slower than for white men after 1979, but for essential hypertension alone (ICD-401), the decline was actually faster for black men.

Generally, similar results were obtained by Sempos and coauthors (7), using an innovative aggregation of codes. In order to circumvent noncomparability in the changeover, they used three disease classifications (coronary heart disease, acute myocardial infarction, and all heart disease) that appeared to provide reasonable smoothness between 1978 and 1979. They found that the decline in coronary heart disease was faster for white males

Table 2. Ratio of rates in 1979 to rates in 1978 for ischemic heart disease (IHD), hypertension (HBP), and their component International Classification of Disease (ICD) codes

Race-sex	IHD	410	411	412	413	HBP	401	402	403	404
Total	0.83	0.97	0.81	0.02	0.98	4.00	8.59	3.12	2.47	1.34
Black women	0.73	1.00	0.89	0.01	1.18	3.61	7.41	2.77	2.76	1.82
Black men..............	0.75	0.99	0.89	0.01	1.10	3.62	7.45	3.16	2.51	1.40
White women	0.82	0.98	0.77	0.01	0.97	4.02	8.50	3.02	2.41	1.33
White men..............	0.85	0.96	0.82	0.02	0.96	4.09	9.12	3.39	2.43	1.20

NOTE: ICD codes 400 and 414 were not present in both ICD–8 and ICD–9. ICD code 405 had a count of 0 in both intervals (see text).

Table 3. Difference between rates in 1979 and rates in 1978 for ischemic heart disease (IHD), hypertension (HPD), and their component International Classification of Disease (ICD) codes

Race-sex	IHD	410	411	412	413	414	HBP	400	401	402	403	404
Total	−75	−5	−1	−276	0.0	207	43	−0.3	26	13	4	0.7
Black women	−83	0.3	−0.5	−212	0.1	129	72	−1	39	25	6	2
Black men............	−116	−2	−1	−300	0.1	187	80	−1	41	32	7	1
White women	−57	−2	−1	−209	0.0	156	35	−0.2	22	10	3	0.5
White men............	−93	−8	−2	−368	−0.1	286	43	−0.2	26	13	4	0.4

Table 4. Ratio and difference of rates in blacks and rates in whites for ischemic heart disease (IHD), hypertension (HBP), and their component International Classification of Disease (ICD) codes for men and women in 1978 and 1979

Category	IHD	410	411	412	413	414	HBP	400	401	402	403	404
Rate ratios:												
Men, 1978............	0.75	0.64	0.91	0.81	0.46	...	2.22	5.69	2.05	2.77	1.52	1.75
Men, 1979............	0.66	0.65	1.00	0.53	0.53	0.65	1.97	...	1.67	2.58	1.57	2.04
Women, 1978........	0.98	0.90	1.11	1.01	0.70	...	2.40	4.64	2.12	2.79	1.94	1.88
Women, 1979........	0.87	0.92	1.28	0.70	0.84	0.83	2.15	...	1.85	2.56	2.22	2.58
Rate differences:												
Men, 1978............	−157	−82	−1	−73	−2	0	17	1	3	9	2	2
Men, 1979............	−180	−76	0	−4	−1	−10	54	0	19	28	4	3
Women, 1978........	−8	−10	1	2	−1	0	16	1	3	9	2	1
Women, 1979........	−34	−7	1	−1	0	−26	53	0	21	24	5	3

Table 5. Ratio of the slopes in the interval 1979–86 to slopes in the interval 1968–78 for ischemic heart disease (IHD), hypertension (HBP), and their component International Classification of Disease (ICD) codes, by sex-race group

Race-sex	IHD	410	411	412	413	HBP	401	402	403	404
Total	0.68	0.61	1.00	0.03	8.24	[1]0.90	6.40	3.75	0.82	0.39
Black women	0.44	0.38	[1]0.78	0.01	3.52	0.67	(2)	2.78	0.13	0.43
Black men..............	0.79	0.67	[1]1.25	0.02	7.69	0.78	3.89	4.65	0.48	0.24
White women	0.57	0.48	0.86	0.01	8.79	0.96	10.02	3.09	[1]0.92	0.40
White men..............	0.86	0.75	[1]1.11	0.05	4.16	1.21	[1]2.24	5.11	[1]1.10	0.43

[1] These 6 tests for difference of the slopes were not statistically significant at the P<.05 level. The remaining 44 tests were statistically significant.

[2] This is the only group for which the slope changed sign, rendering a direct computation of the ratio meaningless.

since 1976 than for the three other sex-race groups.

Unfortunately, their grouping did not permit isolated evaluation of hypertension. The results presented in this paper do not necessarily refute the observations of Sempos and coauthors, whose data suggest that the differential decline may have predated the changeover. Rather, they point to a nonuniform impact of the coding change on individual ICD codes, which in turn, may alter the ability to define disease trends. Since there is no a

Category	Ischemic heart disease (IHD)					Hypertension (HBP)				
	IHD	410	411	412	413	HBP	401	402	403	404
Men, 1978......	0.71	0.62	[1]0.96	[1]0.81	[1]0.68	2.21	[1]2.01	2.61	1.86	1.73
Men, 1979......	0.65	0.55	[1]1.07	0.35	[1]1.25	1.17	3.50	2.37	0.81	[1]0.96
Women, 1978...	[1]1.09	[1]0.97	[1]1.24	[1]1.17	[1]2.12	2.46	(2)	2.46	2.18	1.81
Women, 1979...	[1]0.85	0.76	1.13	0.60	0.85	1.75	2.02	2.21	0.30	1.98

[1] These 13 tests were not statistically significant at the P<.05 level; the remaining 27 comparisons were significant. For only 3 of the code groups (IHD in women, 411 and 413 in men) were the comparison of the slopes not statistically significant in both time intervals.

[2] This was the only comparison for which the signs differed, rendering a direct computation of the ratio meaningless. All other slopes for ICD 401 and all ICD 413 slopes were positive, in contrast to all other slopes for all other codes, which were negative.

'In general, the age-adjusted rates for IHD in black men and women declined more than did the rates for whites between 1978 and 1979. Conversely, the increase in HBP was greater for blacks than for whites between the 2 years.'

priori reason for a differential change in the rates of decline after 1979, coding may play a role, and the observed differences between blacks and whites must be viewed with caution.

That such differential impact actually took place is substantiated by the work of Sorlie and Gold (8) in a recoding study of the rubric "chronic ischemic heart disease." They not only noted the diversity of ratios by State, but they were able to document differences by a direct comparability study. In a multiple regression analysis of the factors that may have influenced coding, both race and sex were independent "risk" factors for classification practices.

It may not be possible to separate the effects of disease coding from underlying epidemiologic processes. As preparations are made for the implementation of ICD–10, and the tradeoff between accuracy and continuity is once again debated, the special problems of heart disease continuity might be reconsidered. Since hypertension is generally considered to have a major impact on blacks, it is especially important that the available data permit direct assessment of this impact.

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