NIOSH

RESEARCH REPORT

Occupational Characteristics of Disabled Workers

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service
Center for Disease Control
National Institute for Occupational Safety and Health

OCCUPATIONAL CHARACTERISTICS OF DISABLED WORKERS

Analysis of Social Security Disability Benefit Awards to Workers during 1969-1972

Illness Effects Section, Surveillance Branch
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National Institute for Occupational Safety and Health
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and

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DISCLAIMER

The data used in this report were extracted and summarized from the Disabled Workers' File, Division of Disability Studies, Office of Research and Statistics, Social Security Administration. Methods for collection and abstraction were selected by the Social Security Administration. Mention of company name or product does not constitute endorsement by the National Institute for Occupational Safety and Health or the Social Security Administration.

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PREFACE

Several issues related to health and disability of U.S. workers are of concern to the Social Security Administration (SSA) and to the National Institute for Occupational Safety and Health (NIOSH). The types of disabilities associated with occupation and variables such as age, sex, and race provide useful information for analysis of the Social Security Disability program. The different social and economic costs incurred by different occupations and industries are directly reflected in trust fund disbursements for disability benefits. The National Institute for Occupational Safety and Health (NIOSH) has the responsibility of conducting research aimed at the identification and control of hazards in the work environment that result in disabling disease. The compilation and analyses of data on disabled workers can lead to greater knowledge of the magnitude and extent of occupational safety and health problems of concern to both SSA and NIOSH.

As a byproduct of the disability insurance program, the SSA collects data on various characteristics of its beneficiaries, including disabling conditions and usual occupations. In a 1967 report [1] published jointly by the Public Health Service and the SSA these data were used in a description of associations

between occupations and disabling conditions for the period from 1959 to 1962. This report presents similar data for the period from 1969 to 1972. It is one product of a cooperative effort formalized by an interagency agreement between NIOSH and SSA.

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by Sex and Race

Occupational Group	Page Number Race/Sex White Male	White Female	Black Male	Black Female	Other Male	Other Female
Total - All Occupations	30	34	38	42	46	50
Professional, Technical, and Managerial Occupations (DOT 001-199)	54	308	516	703	834	973
Clerical and Sales Occupations (DOT 200-299)	57	311	519	706	837	975
Service Occupations (DOT 300-399)	60	314	522	709	839	978
Farming, Fishery, Forestry, and Related Occupations (DOT 400-499)	63	317	525	712	842	981
Processing Occupations (DOT 500-599)	66	320	528	714	845	983
Machine Trades Occupations (DOT 600-699)	69	323	531	716	847	985
Bench Work Occupations (DOT 700-799)	72	326	534	719	849	986
Structural Work Occupations (DOT 800-899)	75	329	537	722	851	988
Miscellaneous Occupations (DOT 900-999)	78	332	540	724	854	989
Special Modifications to DOT (By SSA)	81	335	543	726	857	991
Architecture and Engineering (DOT 001-019)	84	338	546	729	860	993

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Occupational Group	Page Number Race/Sex White Male	White Female	Black Male	Black Female	Other Male	Other Female
Mathematics and Physical Sciences {DOT 020-029}	87	340	548	730	861	994
Life Sciences {DOT 040-049}	90	343	549	731	862	995
Social Sciences {DOT 050-059}	92	345	-	-	863	-
Medicine and Health {DOT 070-079}	93	346	550	732	864	996
Education {DOT 090-099}	96	349	552	734	865	998
Museum, Library and Archival Sciences {DOT 100-102, 109}	99	352	554	736	-	1000
Law and Jurisprudence {DOT 110, 111, 119}	101	354	555	-	867	-
Religion and Theology {DOT 120-129}	104	356	556	737	868	1001
Writing {DOT 130-139}	106	358	557	738	869	1002
Art Work {DOT 141-149}	108	360	558	739	870	1003
Entertainment and Recreation {DOT 150-159}	111	362	559	740	871	1004
Administrative Specialties {DOT 160-169}	114	364	561	741	872	1005
Managerial Work, N.E.C. {DOT 180-189}	117	367	562	742	874	1006
Miscellaneous Professional, Technical, and Managerial {DOT 191-199}	120	370	564	744	876	1008
Stenography, Typing, Filing, and Related Work {DOT 201-209}	123	372	566	746	877	1009
Computing and Account Recording {DOT 210-219}	126	375	568	749	879	1011

Index of Tables (Continued)

Occupational Group	Page Number Race/Sex White Male	White Female	Black Male	Black Female	Other Male	Other Female
Material and Production Recording (DOT 221-229)	129	378	570	751	880	1013
Information and Message Distribution (DOT 230-239)	132	381	572	753	882	1014
Miscellaneous Clerical Work (DOT 240-249)	135	384	574	755	883	1015
Saleswork, Services (DOT 250-259)	138	387	575	756	884	1016
Saleswork, Commodities (DOT 260-289)	141	389	577	757	885	1017
Miscellaneous Merchandising Work (DOT 290-299)	144	392	579	759	887	1019
Domestic Services (DOT 301-309)	147	395	581	761	889	1020
Food and Beverage Preparation and Services (DOT 310-319)	149	398	583	764	890	1022
Lodging and Related Services (DOT 320-329)	152	401	586	767	892	1024
Barbering, Cosmetology, and Related Services (DOT 330-339)	154	404	588	770	893	1026
Amusement and Recreation Services (DOT 340-349)	157	407	590	772	894	1027
Miscellaneous Personal Services (DOT 350-359)	159	409	592	773	895	1028
Apparel and Furnishings Services (DOT 361-369)	162	412	594	776	897	1030
Protective Services (DOT 371-379)	165	415	597	779	899	1032
Building and Related Services (DOT 381-389)	168	417	599	780	901	1033

Index of Tables {Continued}

Occupational Group	Page Number Race/Sex White Male	White Female	Black Male	Black Female	Other Male	Other Female
Plant Farming {DOT 401-409}	171	420	602	783	903	1034
Animal Farming {411-419}	174	422	605	785	906	1035
Miscellaneous Farming and Related Work {DOT 421-429}	177	424	607	786	908	1036
Fishery and Related Work {DOT 431-439}	180	427	610	788	911	1037
Forestry {DOT 441-449}	182	428	612	-	912	1038
Hunting, Trapping, and Related Services {DOT 451-452}	184	429	613	-	913	-
Agricultural Services {DOT 461-469}	185	430	614	-	914	-
Metal Processing {DOT 500-509}	187	431	615	789	915	-
Ore Refining and Foundry Work {DOT 510-519}	190	432	617	790	916	-
Processing, Food and Related Products {DOT 520-529}	193	433	620	791	917	1039
Processing, Paper and Related Materials {DOT 530-539}	196	436	622	793	919	-
Processing, Petroleum and Related Products {DOT 540-549}	198	437	624	794	920	-
Processing, Chemicals and Related Products {DOT 550-559}	200	438	625	795	921	-
Processing, Wood and Wood Products {DOT 560-569}	203	440	627	796	922	-
Processing, Nonmetallic Minerals and Related Products {DOT 570-579}	205	441	628	797	923	1041

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Occupational Group	Page Number Race/Sex White Male	White Female	Black Male	Black Female	Other Male	Other Female
Processing, Leather and Textiles (DOT 580-589)	208	443	630	798	925	1041
Processing, N.E.C. (DOT 590-599)	211	445	632	799	925	-
Metal Machining (DOT 600-609)	214	447	634	800	926	-
Metalworking, N.E.C. (DOT 610-619)	217	450	636	801	928	1043
Mechanical Repairing (DOT 620-639)	220	453	638	803	929	1044
Paperworking (DOT 640-649)	223	455	641	804	931	1045
Printing (DOT 650-659)	225	457	642	805	932	1046
Wood Machining (DOT 660-669)	228	459	644	806	933	-
Machining, Nonmetallic Minerals and Related Materials (DOT 670-679)	231	461	646	-	-	1047
Textile Machine Work (DOT 680-687, 689)	233	462	647	807	934	1048
Machine Work, N.E.C. (DOT 690-699)	236	465	649	809	935	1049
Fabrication, Assembly, and Repair of Metal Products, N.E.C. (DOT 700-709)	238	467	651	810	936	1050
Fabrication and Repair of Scientific and Medical Apparatus, Photographic and Optical Goods, Watches and Clocks, and Related Products (DOT 710-719)	241	470	653	812	937	1051
Assembly and Repair of Electrical Equipment (DOT 720-729)	244	472	654	813	938	1052

Occupational Group	Page Number Race/Sex White Male	White Female	Black Male	Black Female	Other Male	Other Female
Fabrication and Repair of Products Made from Assorted Materials {DOT 730-739}	247	475	656	814	939	1053
Painting, Decorating, and Related Work {DOT 740-749}	249	477	657	815	940	-
Fabrication and Repair of Plastics, Synthetics, Rubber, and Related Products {DOT 750-759}	251	479	659	816	941	1054
Fabrication and Repair of Wood Products {DOT 760-769}	253	481	661	817	942	1055
Fabrication and Repair of Sand, Stone, Clay, and Glass Products {DOT 770-779}	256	483	663	-	943	1056
Fabrication and Repair of Textile, Leather, and Related Products {DOT 780-789}	259	485	664	818	944	1057
Bench Work, N.E.C. {DOT 790-799}	262	488	666	820	945	1059
Metal Fabricating, N.E.C. {DOT 800-809}	264	490	668	821	946	-
Welding, Flame Cutting, and Related Work {DOT 810-819}	267	492	670	822	948	1060
Electrical Assembly, Installing, and Repairing {DOT 820-829}	270	494	672	823	950	1061
Painting, Plastering, Waterproofing, Cementing, and Related Work {DOT 840-849}	273	496	674	824	952	1062
Excavating, Grading, Paving, and Related Work {DOT 850-859}	276	498	676	-	954	-

Index of Tables {Continued}

Occupational Group	Page Number Race/Sex White Male	White Female	Black Male	Black Female	Other Male	Other Female
Construction, N.E.C. {DOT 860-869}	279	499	679	825	956	1063
Structural Work, N.E.C. {DOT 891-899}	282	501	682	826	958	-
Motor Freight Transportation {DOT 900-909}	285	503	685	827	960	1064
Transportation Work, N.E.C. {DOT 910-919}	288	505	688	828	962	1065
Packaging and Materials Handling {DOT 920-929}	291	507	691	830	964	1066
Extraction of Minerals {DOT 930-939}	294	510	694	832	966	-
Logging {DOT 940-949}	297	511	696	-	968	-
Production and Distribution of Utilities {DOT 950-959}	300	512	698	-	969	1068
Amusement, Recreation, and Motion Picture Work, N.E.C. {DOT 960-969}	303	513	700	-	971	-
Graphic Art Work {DOT 970-979}	305	514	701	833	972	1069

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INTRODUCTION

Since 1956 the Social Security Administration (SSA) has been paying cash benefits to eligible disabled workers. To qualify for benefits, workers disabled after age 30 must have worked in covered employment for at least 5 of the 10 years immediately preceding the onset of disability; progressively fewer years of coverage are required for younger workers. To be eligible, a worker must be unable to engage in any substantial gainful activity because of a medically determinable physical or mental impairment that has lasted or can be expected to last for at least 12 months or to result in death.

During the 1969 to 1972 period, approximately 96 percent of the 80 million workers in the United States were insured under the program and about 1,566,420 of these workers received Social Security disability benefits. In recent years, more than 400,000 workers annually have been granted disability benefits. Both SSA and NIOSH recognize that the data collected in the adjudication of these claims is of considerable value for occupational health surveillance. Although these records are compiled for administrative purposes, they offer valid and useful statistics for possible identification of specific occupational groups for in-depth research.

In this report, these data on SSA disability awards for the years 1969 through 1972 are used as a basis for establishing associations between disabling conditions and occupations among workers covered by the Social Security disability insurance program. The report presents race-and sex-specific, age-adjusted, proportional morbidity ratios (PMR's) by disabling condition and occupation. It also presents estimates of numbers of disabled workers by disabling condition, occupation, age, sex, and race. The objective is to provide a reference for epidemiological investigations of occupational morbidity.

The source of data for this report was the Continuous Disability History Sample (CDHS) file. Technical Note 2 in the Appendix provides a general description of this sample, which includes approximately 20 percent of the total awards made from 1969 to 1972. Characteristics selected from this file include age, race, sex, occupation, and diagnosis of primary disabling condition. Age of the worker was defined as age in years at the date of the benefit award. Workers were grouped by age into 5-year intervals for those aged 40 to 64. The remaining workers fell into two age groups--those under 40 years and those over 64 years (the last group includes workers age 65 and older at the time they were awarded benefits for disabilities that occurred before they became 65). Race was categorized as black, white, or other, and sex, as male or female. For purposes of this report, the "disabling condition" is the condition that was diagnosed as the primary cause of the individual's disability.

They are coded according to the Eighth Revision of the International Classification of Diseases, Adapted for Use in the United States (ICDA) (2). The 65 diagnostic categories for disabling conditions used in this report were chosen prior to the analysis and are based on previous research and professional judgment. "Occupation" represents the disabled worker's longest full-time occupation in the 10 years preceding the alleged date of the disability, and it is coded according to the occupational classification in the Dictionary of Occupational Titles (DOT) (3). The occupations are grouped according to one-digit and two-digit DOT categories, which generated 83 detailed and 10 major occupational classifications.

Race-and sex-specific, age-adjusted PMR's were used to describe empirical associations between occupation and disabling conditions. The PMR for a selected occupation with respect to a specified disabling condition for the 1969 to 1972 period was defined as the ratio of the observed number of newly disabled workers to the corresponding expected number. For each age group the expected number was equal to the proportion of disabled workers for all occupations, with the specified condition multiplied by the total number of disabled workers for the selected occupation. A more detailed explanation of this measure and its estimation from the Continuous Disability History Sample appears in Technical Note 1 of the Appendix.

The PMR's presented in this report are estimates of national

values and are subject to sampling error. Estimates of the standard errors of these PMR's are also presented so that the risk of various magnitudes of sampling error may be determined. Estimation of the standard errors of the PMR's was complicated by the fact that the PMR estimators are ratios and there is no known expression for the standard error. This difficulty was overcome by the use of a sample replicate procedure, which is described in Technical Note 1 of the Appendix.

LIMITATIONS OF DATA

The SSA disability program data, like data from other routine sources, are inadequate for thorough epidemiological study of disabling diseases. Limitations result from having only one occupation and no industry recorded for each worker when, in reality, workers may change from one occupation or industry to another and exposures in the same occupation may vary by industry. Moreover, additional factors may affect associations between occupations and disabling conditions. These factors may be classified as demographic, socioeconomic, environmental, or being related to the physical or mental attributes of the workers. Without information on factors such as residence (urban vs. rural), life style, smoking habits, diet, hobbies, medical history, or previous jobs held, it is not possible to determine the extent, if any, of confounding of such factors in the relationship of disabling disease with the selected occupation.

Limitations of using "usual" occupation have been studied previously by Gamble and Spirtas [4], and studies by Lansing and Mueller [5] and by Steinberg [6] have dealt with occupational mobility. These studies indicated that changes are most likely to take place between occupations in which work requirements are similar, that changes occur most frequently among individuals who have limited training, and that changes in occupation decrease after age 40. Because the disabled worker population in this study was relatively old [the estimated median age was greater than 55], their occupational stability, was probably high. Moreover, it is reasonable to believe that the occupation indicated is sufficiently representative of the worker's major lifetime experience.

Proportional morbidity ratios were used in this report because the sizes of the various occupational populations at risk are difficult to estimate with sufficient accuracy for computation of actual disability rates. The PMR is a measure of relative incidence. Essentially, a PMR for a particular occupational group and a specific disabling condition compares the proportion of all disabled workers in that occupational group who have that disabling condition to the proportion of all disabled workers in all occupations who have the same disabling condition. If the PMR is greater than 100 it implies that workers in that occupation tend to be disabled by that particular condition relatively more often. The actual rate at which workers in that occupational group are disabled by that condition, however,

may be more than, equal to, or less than the corresponding rate for all workers of all occupations. The use of PMR's might be compared to comparisons between relative sizes of pieces from two different pies. The first piece may be one-third of the first pie whereas the second piece is only one-fourth of the second pie; however, if the second pie has a 20-inch diameter and the first pie has a 10-inch diameter, the second piece is absolutely larger than the first piece, even though the first is proportionately the larger. Thus, comparisons of PMR's for different occupational groups must be done with great caution.

ASTERISK NOTATION IN TABLES

The appearance of one or two asterisks after the values of the PMR's presented in this report represents the outcome of the F-test described in Technical Note 1 in the Appendix. No asterisk appears if the estimated PMR does not differ from 100 by a statistically significant amount. A single asterisk indicates that the difference is statistically significant at the five percent level, and two asterisks indicate statistical significance at the one percent level. In this context, the hypothesis tested is that if all disability insurance beneficiary records had been analyzed, rather than just a sample, then the value of the observed PMR would be 100. A "statistically significant" difference means that the hypothesis has been rejected. These statistical test results are very useful for

accumulating fresh evidence for or against specific hypotheses formulated without use of this report. They are less useful, and potentially misleading, if the occurrence of one or more "statistically significant" PMR's for an occupational group is used as an indication of an unusual disability pattern for that occupational group. Because 65 PMR statistical tests are reported for each occupational group, the probability that one or more of these achieves the 0.05 {0.01} significance level is greater than 0.05 {0.01} for any occupational group, even if it has no unusual disability pattern. A more detailed discussion of the measures used for this report, the data limitations, the CDHS study file, and sampling variance are included in the appendix.

RESULTS

During the 1969-1972 period, an estimated 1,566,420 disabled workers were awarded Social Security disability benefits. Of these, 73 percent were men and 27 percent were women. Eighty-five percent of the beneficiaries were white, 14 percent were black, and about 1 percent were of other races. Median ages were 56.4 years for white men, 53.7 years for black men, 54.7 years for men of other races, 56.1 years for white women, 55.2 years for black women, and 52.8 years for women of other races.

The most prevalent disabilities were those conditions classified under diseases of the circulatory system (31.5 percent), followed by disabilities involved with diseases of the musculoskeletal system (15.4 percent). These disabling conditions ranked in this same order within all race-and sex-specific groups. Mental disorders ranked third in all subgroups except white women, for whom neoplasms ranked slightly ahead of the mental disorders. Fourth and fifth among the cited disabling conditions were accidents and neoplasms (for all groups but white women, for whom mental disorders and accidents ranked fourth and fifth.

The highest proportion of disabled workers were in the service occupations (15.9 percent), followed by the structural work

classification (13.3 percent), and the clerical and sales classification (13.2 percent). An additional 10.6 percent were classified as professional, technical, and managerial, and 9 percent were in the machine trades occupations.

Tables 1-1, 1-2, 2-1, 2-2, 3-1, and 3-2 present the distribution of disabled workers for the years 1969-1972 by age, sex, and race. Table 4-1 presents age-adjusted proportional morbidity ratios and standard errors for white males, Table 4-2 for white females, Table 5-1 for black males, Table 5-2 for black females, Table 6-1 for other males, and Table 6-2 for other females.

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APPENDIX

TECHNICAL NOTES ON METHODS

1. ESTIMATION OF PROPORTIONAL MORBIDITY RATIOS AND STANDARD ERRORS

Definition of the PMR

The proportional morbidity ratio (PMR) is the measure used in this report to study associations between particular occupations and specific disabling conditions. This ratio of an observed number to a number expected if no association existed is multiplied by 100 for more convenient scaling. The observed number in the PMR ratio is the number of workers granted disability benefit awards for a specific disabling condition. The denominator is the number expected if the proportion of all disability benefit awards for a specific disabling condition within one particular occupation were the same as for all occupations combined. Because the age distributions of different occupational groups vary and because the disability condition may be related to age, the PMR is age-adjusted by calculating the expected number of disability awards for each age group. The

denominator is obtained by multiplying the proportion of all disability cases involving a specific disabling condition by the number of disabled workers in the specific occupational group. These are summed to get the total number of expected benefit awards.

In this study, PMR's are calculated for each sex and race. For the ith occupational group and kth disability group, the proportional morbidity ratio, PMR_{ik}, is mathematically defined as:

$$\{1\} \quad PMR_{ik} = \{O_{ik}/E_{i.k}\} \times \{100\}$$

for $i = 1, 2, \ldots, 93$ occupational groups

and $k = 1, 2, \ldots, 65$ disabling conditions,

where

O_{ik} is the observed number of awards for occupation i and disabling condition k; and $E_{i.k}$ is the expected number of awards for occupation i and disabling condition k.

The terms in equation {1} are defined as follows:

$$\{2\} \quad O_{ik} = \sum_{j=1}^{7} \sum_{l=1}^{55} \sum_{y=1969}^{1972} D_{i\,j\,k\,l\,y}$$

where

$D_{i\,j\,k\,l\,y}$ is the number of disability awards for occupation i, with $i = 1, 2, \ldots, 93$

occupations;

age group of the awardee j, with j = 1, 2, ..., 7

where

1 represents those younger than 40 years of age,

2, 3, ..., 6 represents respective 5-year age intervals for those 40 to 64 years of age, and

7 represents those older than 64 years of age;

disabling condition k, with k = 1, 2, ..., 65 disabling conditions;

state or territory, l, in which the award is granted, with l = 1, 2, ..., 55; and

year, y, in which the award is granted, with y = 1969, 1970, 1971 and 1972.

{See Technical Note 2 for a description of the stratification factors in the sample design.}

$$\{3\} \quad E_{i.k} = \sum_{j=1}^{7} E_{i\,j\,k}$$

where

E_{ijk} is the expected number of disability awards for occupation i, age group j and for disability k {the range of subscripts are the same as in equation 2 and are not repeated unless there

is a change}.

The value of E_{ijk} in equation {3} is defined as:

{4} $E_{ijk} = D_{ij...} \times D_{.jk..}/D_{.j...}$

where

"." is used to denote a summation over the range of the subscript it replaces; thus:

$D_{ij...}$ is the total number of awards for occupation i, for age group j, for all 65 disabling conditions, for all 55 states and territories, and for the entire period from 1969 to 1972;

$D_{.jk..}$ is the total number of awards for all 93 occupations, for age group j, condition k, for all 55 states and territories, and for the entire period; and

$D_{.j...}$ is the total awards for all 93 occupations for age group j, for all 65 disabling conditions, for all 55 states and territories, and for the entire period.

PMR_{ik} is a measure of the degree to which workers in occupation i tend to receive awards for disabling condition k in greater proportion, if $PMR_{ik} > 100$, or lesser proportion, if $PMR_{ik} < 100$, or in the same proportion, if $PMR_{ik} = 100$, than workers in all occupations, after adjustment for differences in age distributions. The age adjustment

used, however, assumes that the association between an occupation and a disabling condition does not vary across age groups. If that is not the case, then no single measure is appropriate and each age group should be studied separately.

Estimation of the PMR

The definitions that have been presented apply to the entire population of disability awards for the 1969 to 1972 period. Information about the PMR's for all occupational groups and disabling conditions under study was obtained from a sample that had been statistically selected earlier, as described in Technical Note 2. Use of this information required that methods be established for estimating the PMR and its standard error from the sample. In this report the PMR is estimated by a straight-forward application of equations (1) to (3) to the sample data and the use of estimators to replace population values; the standard error of the estimator of the PMR is estimated by a sample replicate procedure.

The estimator of PMR_{ik} is denoted by $\hat{PMR}_{ik}$ and is given by:

$$(5) \quad \hat{PMR}_{ik} = \{\hat{O}_{ik}/\hat{E}_{i.k}\}x\{100\},$$

where

$\hat{O}_{ik}$ and $\hat{E}_{i.k}$ correspond to estimators of the

observed and expected, respectively, numbers of disability benefit awards for occupation i and disability condition k for all age groups, for all states and territories, and for the entire period from 1969 to 1972.

The basic "building blocks" for the estimators, $\hat{O}_{ik}$ and $\hat{E}_{i.k}$, are the estimators for the D_{ijkly}'s, hereafter designated by $\hat{D}_{ijkly}$'s. $\hat{D}_{ijkly}$ is defined as:

{6} $$\hat{D}_{ijkly} = d_{ijkly} \times W_{ly}$$

where

d_{ijkly} is the number of awards observed in the sample for occupation i, for age group j, for disabling condition k, for state or territory l, and for year y; and W_{ly} is an inflation factor equal to the reciprocal of the sampling fraction multiplied by a ratio estimator adjustment factor. {See Technical Note 2, page 24.}

The $\hat{O}_{ik}$'s are obtained by replacing each D_{ijkly} in equation {2} by its estimator, $\hat{D}_{ijkly}$. Similarly, the $\hat{E}_{i.k}$'s are obtained by replacing each term, factor, or divisor in equations {3} and {4} with its estimator. Each factor in equation {4} is a particular sum of some of the D_{ijkly}'s and the estimator of such a sum is simply the sum of the estimators of the D_{ijkly}'s in that sum, e.g.,

$$\{7\} \quad \hat{D}_{ij\ldots} = \sum_{k=1}^{65} \sum_{l=1}^{55} \sum_{y=1969}^{1972} D_{ijkly}.$$

Estimation of the Standard Error of $\hat{PMR}$: The Sample Replicate Procedure.

It is difficult to obtain an estimator of the standard error of $\hat{PMR}_{ik}$ for confidence interval estimation and hypothesis testing. $\hat{PMR}_{ik}$ is a ratio, and both the numerator and denominator are subject to sampling error. Moreover, the denominator is a sum of terms, each of which is a ratio of the product of two factors to another quantity, and all are subject to sampling errors. Because of these complexities, there is no known expression for the variance of $\hat{PMR}_{ik}$ involving parameters that can be estimated. In addition, the application of the large sample theory to approximate an estimator of the standard error would be difficult, and the rate of convergence of such estimators to their asymptotic limits is not known. The sample replicate approach {see, for example, Kish 7} was chosen because it is practical, efficient, and statistically sound. As applied to this study, the sample is randomly divided into R mutually exclusive subsamples that have the same stratification and other design characteristics of the total sample except that the sampling fractions are {1/R}th that of the total sample. A PMR is estimated for each of the R subsamples. These are equivalent to a simple

random sample of size R from the total population of PMR estimates from such subsamples. The estimate of standard error is obtained from the "sample" variance of this "sample" by application of the usual formulas.

In this study R was 20. The total sample was randomly divided into 20 subsamples within each stratum so that every possible sample could occur with equal probability. The population was stratified by state and/or territory and by year, which produced 220 strata. Random division into 20 subsamples was done independently in the samples from each of these 220 strata except those that had been sampled 100%. The strata with 100% samples were included in their entirety in all 20 subsamples.

The estimation procedure described previously was then applied to obtain an estimate of PMR_{ik} in each subsample. For the rth subsample the estimator $_r\hat{PMR}_{ik}$ is given by:

{8} $$_r\hat{PMR}_{ik} = \{_r\hat{O}_{ik} / _r\hat{E}_{i.k}\} \times \{100\}$$

where

$_r\hat{O}_{ik}$ and $_r\hat{E}_{i.k}$ are, respectively, the estimators of O_{ik} and $E_{i.k}$ from the rth subsample.

Both $_r\hat{O}_{ik}$ and $_r\hat{E}_{i.k}$ are obtained by applying equations {6} and {7} to the rth subsample, except that the weight or inflation factor, $_rW_{ly}$ is now:

$$\{9\} \quad {}_{r}W_{ly} = 20\ W_{ly}$$

because the sampling fraction for any subsample is {1/R}th or {1/20}th that of the total sample. The sample mean of the ${}_{r}PMR_{ik}$'s was obtained as follows:

$$\{10\} \quad \overline{PMR}_{ik} = \sum_{r=1}^{20} {}_{r}\hat{PMR}_{ik} \ /20.$$

The estimator of the variance of $\overline{PMR}_{ik}$ was obtained by use of the fact that the R = 20 values of ${}_{r}\hat{PMR}_{ik}$ represent a randomly selected sample of size 20 from the population of values of ${}_{r}\hat{PMR}_{ik}$ that would be generated by repeated random sampling, without replacement from the population of disability benefit awards for the period, with samples of the same size and sampling design as the subsamples. The estimator of the variance of $\overline{PMR}_{ik}$ for this study is given by

$$\{11\} \quad \hat{V}\{\overline{PMR}_{ik}\} = \frac{\sum_{r=1}^{20} \{{}_{r}\hat{PMR}_{ik} - \overline{PMR}_{ik}\}^{2}}{19 \times 20}$$

This is slightly biased on the high side because it ignores the finite population correction, which cannot be applied because ${}_{r}\hat{PMR}_{ik}$ cannot be expressed as a sum of statistics from the individual strata and the finite population correction factors vary by strata. An estimator for the standard error of $\overline{PMR}_{ik}$ is given by

$$(12)\quad \hat{S}\{\overline{PMR}_{ik}\} = \sqrt{\hat{V}\{\overline{PMR}_{ik}\}}$$

This is used as the estimator of the standard error of $\hat{PMR}_{ik}$ in this report and appears in the tables under the entries labeled SE{PMR}. {Note that $\overline{PMR}_{ik}$ is not identical to $\hat{PMR}_{ik}$.} Confidence intervals constructed with $\hat{S}\{\overline{PMR}_{ik}\}$ tend to be somewhat too wide, and Type I error probabilities for statistical tests are actually somewhat lower than the nominal ones.

Confidence Interval Estimation

Because of the large sample size, it is assumed that the sampling distribution of $\hat{PMR}_{ik}$ is normal. Consequently,

$$(13)\quad \{\hat{PMR}_{ik} - PMR_{ik}\} / \hat{S}\{\overline{PMR}_{ik}\} = T_{ik}$$

has, approximately a t distribution with 19 degrees of freedom. Thus, a 95 percent confidence interval for PMR_{ik} is given approximately by:

$$(14)\quad \hat{PMR}_{ik} \pm 2.09\ \hat{S}\{\overline{PMR}_{ik}\}$$

where

2.09 is the 97.5th percentile of the t distribution with 19 degrees of freedom.

To use equation (14) for a 95% confidence interval estimate for a particular occupation and a selected disability condition, one would find the estimate of PMR_{ik} in Tables

4-1, 4-2, 5-1, 5-2, 6-1, or 6-2 under the entry labeled PMR. The corresponding value for $\hat{S}\{\overline{PMR}_{ik}\}$ would be found in the same Tables under the entry labeled SE{PMR}. These intervals provide approximate information on the value of PMR_{ik}.

Hypothesis Testing

Testing the hypothesis that $PMR_{ik} = 100$ as opposed to the alternative that $PMR_{ik} \neq 100$ may be of interest. An approximate test, ignoring any possible bias in $\hat{PMR}_{ik}$, is obtained from the statistic F where:

$$\{15\}\quad F = \{\{\hat{PMR}_{ik} - 100\}/\hat{S}\{\overline{PMR}_{ik}\}\}^2$$

which approximates an F distribution with 1 and 19 degrees of freedom under the hypothesis that $PMR_{ik} = 100$.

Values for using equation {15} can be obtained in the same manner as described for confidence interval estimation.

2. CONTINUOUS DISABILITY HISTORY SAMPLE {CDHS}

The Continuous Disability History Sample {CDHS} is a data file that is longitudinal in nature to support various studies of the disability applicant population. This has been described in detail by SSA {8}. Data on new applicants for disability insurance benefits that meet

the selection criteria are added to the file each year at the time their claims are processed. The file is updated annually to accumulate new earnings and entitlement data for each applicant. The CDHS contains data from the several files on disabled workers. The data for this report were obtained from the Disability Data Record (DDR), later termed the Disabled Persons Record (DPR). This record contains data on allowances and denials from 1967 through the latest update.

The DDR's or DPR's for the CDHS represent a statistically selected sample from the Disabled Data Record File of the Bureau of Disability Insurance, which contains all records of workers granted disability benefit awards. These records were stratified by state, territory, or foreign country and by year. One stratum per year was designated for each state and each territory and one for all foreign territories combined. A sample was selected from each stratum independently by simple random sampling at a rate varying from 10 to 100 percent. Individual stratum rates varied from year to year and depended on the total number of disabled benefit awards granted the previous year. The sample rate was made inversely proportional to the total awards for the previous year. Additionally, individual stratum rates were selected so that the overall sampling rate was approximately 20 percent.

Estimation of Numbers of Disabled Workers

The procedure for estimation of national numbers of cases from the sample required determination of inflation weights to be applied to the sample data. These were termed W_{1y}'s in Technical Note 1 and were developed by a two-step procedure. The reciprocals of the sampling rates were used as initial weights to obtain estimated total numbers of disabled benefit awards for all types of disabilities, all occupations, all races, and both sexes for each stratum. Because these totals were known exactly, the initial weights could be adjusted so that the inflation procedure estimates for the totals would agree with the known totals. The adjusted weights were the ones used. Estimates produced were, therefore, ratio estimates.

Sampling Errors of Estimates

Estimates based on samples can be expected to differ from figures that would have been obtained if the entire population had been measured. The particular sample selected for this study was one of many similar probability samples of the same size that might have been selected by chance under the same specifications. Each of the possible samples would yield somewhat different sets of results. The deviation of a sample estimate from the value that would have been obtained if the entire population had been studied is

called the sampling error. The standard error of an estimate is a measure of the variation among the estimates from the possible samples and thus is a measure of the precision with which an estimate from a particular sample approximates the average result of all possible samples. It is a measure of one component of sampling error. The standard error may be used to define confidence intervals or ranges that would include the average result of all possible samples, as follows with a specified probability:

a. Approximately 68 percent of the intervals from one standard error below to one standard error above the derived estimate would include the average value of all possible samples.

b. Approximately 95 percent of the intervals from two standard errors below to two standard errors above the derived estimate would include the average value of all possible samples.

c. Approximately 99 percent of the intervals from two and one-half standard errors below to two and one-half standard errors above the derived estimate would include the average value of all possible samples.

Standard errors for PMR's are provided in the report tables under the SE{PMR} entries. As noted in Technical Note 1, these were produced by a replicate procedure. In contrast, guides to standard errors for estimates of numbers of disabled workers are provided in Tables A-1 and A-2. These estimates were developed from usual procedures for stratified probability samples, i.e., as though the inflation weights were the unadjusted reciprocals of the sampling probabilities. Thus, the estimates of standard errors tend to be hign.

Guides for approximate levels of standard errors are presented in two ways. Table A-1 shows approximate standard errors associated with estimates of numbers of awards by absolute size for various ranges of absolute size of the estimate. Table A-2 shows approximate standard errors of estimated percentages for various ranges of percentages.

Nonsampling Variability

In addition to sampling errors, the estimates are subject to operational errors of collection, coding, and transcription. Collection errors include those created by problems in linking large separate data files. Such errors would also occur if a complete study were to be conducted under the same conditions. Explicit measures of their effects

generally are not available. Many of the operational errors, however, were detected and corrected when the data were edited.

Table A-1: Guide for Standard Errors of Numbers of Disabled Workers* Estimated from the Continuous Disability History Sample by Magnitude of the Estimate of Numbers of Disabled Workers

Magnitude of Estimate of Number of Disabled Workers*	Standard Error of the Estimate
1-999	**
1,000	30
2,500	47
5,000	67
7,500	82
10,000	95
25,000	149
50,000	210
75,000	255
100,000	292
250,000	440
500,000	567
750,000	618

*Disabled Workers means workers granted SSA benefit awards for disabilities.

**For estimated numbers smaller than 1,000, an approximation for the standard error is the square root of the estimate.

Table A-2: Guide for Standard Errors of Percentages of Disabled Workers* Estimated from the Continuous Disability History Sample by Magnitude of the Estimated Percentage and the Base of the Percentage.

Base of Percent	ESTIMATED PERCENTAGE											
	1 or 99	2 or 98	5 or 95	8 or 92	10 or 90	15 or 85	20 or 80	25 or 75	30 or 70	35 or 65	40 or 60	50
2,500	0.19	0.27	0.42	0.52	0.57	0.68	0.76	0.83	0.87	0.91	0.93	0.95
5,000	0.13	0.19	0.29	0.37	0.40	0.48	0.54	0.58	0.62	0.64	0.66	0.67
7,500	0.11	0.15	0.24	0.30	0.33	0.39	0.44	0.48	0.50	0.53	0.54	0.55
10,000	0.09	0.13	0.21	0.26	0.29	0.34	0.38	0.41	0.44	0.46	0.47	0.48
25,000	0.06	0.08	0.13	0.16	0.18	0.22	0.24	0.26	0.28	0.29	0.30	0.30
50,000	0.04	0.06	0.09	0.12	0.13	0.15	0.17	0.18	0.20	0.20	0.21	0.21
75,000	0.03	0.05	0.08	0.09	0.10	0.12	0.14	0.15	0.16	0.17	0.17	0.17
100,000	0.03	0.04	0.07	0.08	0.09	0.11	0.12	0.13	0.14	0.14	0.15	0.15
250,000	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.08	0.09	0.09	0.09	0.10
500,000	0.01	0.02	0.03	0.04	0.04	0.05	0.05	0.06	0.06	0.06	0.07	0.07
750,000	0.01	0.02	0.02	0.03	0.03	0.04	0.04	0.05	0.05	0.05	0.05	0.06

*Disabled Workers means workers granted SSA benefit awards for disabilities.

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