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Validation of a model for estimating state and local prevalence of serious mental illness

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Abstract

This study addresses an ongoing problem in mental health needs assessment. This involves estimating the prevalence of an identified problem, specifically serious mental illness (SMI), for local areas in a reliable, valid, and cost-effective manner. The aim of the study is the application and testing of a recently introduced methodology from the field of small area estimation to determining SMI rates in the 48 contiguous US states, and in local areas of Massachusetts. It uses 'regression synthetic estimation fitted using area-level covariates', to estimate a model using data from the 2001–2002 replication of the National Comorbidity Study (n = 5593) and apply it, using 2000 STF-3C Census data, to various state and local areas in the United States. The estimates are then compared with independently collected SMI indicators. The estimates show not only face validity and internal consistency, but also predictive validity. The multiple logistic model has a sensitivity of 21.1% and a specificity of 95.1%, based largely on socio-economic disparities. Pearson r validity coefficients for the area estimates range from 0.43 to 0.75. The model generates a national estimate of SMI adults of 5.5%; for the 48 states, rates ranging from 4.7% to 7.0%; and for Massachusetts towns and cities, 1.1% to 7.5%. *Copyright © 2009 John Wiley & Sons, Ltd.*

Introduction

A pivotal element of needs assessment, resource allocation, and service planning is the estimation of the prevalence of persons experiencing designated problems. This is especially difficult when those with serious mental illnesses (SMIs) are considered. This is a very large group that is reported to consist of between 2.8% and 7.2% of the populations of the United States and other developed nations (Lora *et al.*, 2007, p. 343), one which has been ranked as having one of the top 10 public health problems due to the substantial and persistent levels of disability involved (Üstün, 1999). It is also a difficulty for which there is continuing controversy about definition, and a virtual absence of cost-effective and reliable methods for its estimation on the local level.

Considerable progress has been made in recent years in the development of national estimates of rates of mental illness through large-scale psychiatric epidemiological surveys, most notably the 2001–2002 replication of the National Comorbidity Survey (NCS-R) (Kessler *et al.*, 2005a; Kessler *et al.*, 2005b). Unfortunately such sophisticated methods are not within the financial reach of most local communities which are regularly faced with problems involving the equitable allocation of scarce resources to local service systems. Yet, with the continuing development of a variety of regression-based synthetic estimation methodologies (see Bajekal *et al.*, 2004; Pickering *et al.*, 2005; Schaible, 1996), it has become increasingly feasible to use a mixed methods design to apply the results of national surveys, such as the NCS-R, when used in conjunction with other sources of data, to produce synthetic estimates of the prevalence of SMI for state and local areas. This study specifically involves the continued development of such a modeling and estimation methodology, and conducts an initial set of tests of it, primarily through the comparison of the generated estimates with independent sources of data.

Background

For several decades now research in psychiatric epidemiology has moved beyond the problem of defining the seriously mentally ill, to refining measurement strategies and testing their reliability and validity. Recent tests on the World Health Organization's Composite International Diagnostic Inventory (WHO-CIDI), which has been used in the NCS-R, as well as a variety of other national studies, has increasingly demonstrated its reliability and validity (Kessler *et al.*, 2003; Kessler *et al.*, 2005a; Kessler *et al.*, 2005b; Parabiaghi *et al.* 2006; Perälä *et al.*, 2007). These tests, however, have generally been restricted to establishing psychometric properties on the individual level. An ongoing need involves the measurement of local population rates of SMI, something that has generally not been possible with national surveys due to their lack of power for direct inference to local areas. This study, thus, focuses on this later problem of population estimation. Unless local mental health authorities have substantial research budgets, one of the only viable options is the use of data from state-of-the-art national surveys, such as the NCS-R, as a basis for the generation of synthetic estimates. Kessler, the principal investigator of the NCS-R, also points out that 'In terms of estimation methods, it is possible to generate individual-level predicted probabilities of SMI from the screening scales . . . and to generate state-level estimates of SMI from these transformed scores using standard small-area estimation methods' (Kessler *et al.*, 2003, p. 188).

Since the early 1990s local area estimation methods have been developed mostly outside of the mental health field (Schaible, 1996), and have rarely been used in a systematic manner within mental health. One of the few efforts along these lines was by Kamis-Gould and Minsky (1995) in New Jersey who attempted to use such methods, but only with services and general demographic data. Periodically, there have been efforts to generate factor scores of demographic variables, but their interpretation *vis-à-vis* of actual rates of SMI have been ambiguous at best, as they have generally not included prevalence estimates as a core data source. In contrast, Hudson (1998) developed a national model of variations in homeless rates on the county level, accounting for both random and systematic forms of error, and was able to validate them against independent studies.

Methodology

Overview

This study aims to generate valid state and local-level estimates of SMI in the United States through the application of small area estimation methodologies to the analysis of data collected as part of the replication of the US National Comorbidity Study (Kessler and Merikangas, 2004). It does this specifically through an adaptation of a methodology developed by the UK's Office of National Statistics, known as 'regression synthetic estimation fitted using area-level covariates' (Heady *et al.*, 2003). This initially involves the estimation of a predictive model of variations in occurrence of SMI on the individual level. This first stage of the project, which uses multiple logistic regression with the NCS-R data, is in some respects a replication of work done by Kessler and his colleagues (Kessler *et al.*, 2005a; Kessler *et al.*, 2005b). In the second stage, the coefficients derived from the foregoing model are used with a parallel set of predictors on the area level, using data obtained through the 2000 census, and coded using the same categories as used to estimate the individual-level model, to compute area-level estimates for 48 US states and zipcodes and towns and cities in a sample state (Massachusetts). In the third stage, the resulting estimates for several levels of geographic aggregation – the zipcode, town, state, as well as national levels – are then correlated and regressed on independent indicators of SMI to assess the validity of the project's estimates.

Data sources

Three sources of data are used in this study: (i) individual-level data downloaded from the publicly-accessible version of the replication of the National Comorbidity Study, (ii) census data obtained from the 2000 Decennial Census from the STF3 long-form, and (iii) several data items used for validation that were computed as part of an earlier study, from both the census data as well as acute hospitalization rates computed by this researcher from the case mix discharge data produced by the Massachusetts Division of Health Care Finance and Policy (MDHCFP, 1998).

Individual data

The individual level data consists of items that were collected as part of a national probability sample of English speaking households in the 48 contiguous US states in 2001–2002, specifically, the NCS-R. The data used involved a subset of the original sample of 9282 individuals who completed a longer set of interviews, and this consisted of a sample of 5493 adults 18 and over. Rather than attempting to develop a new measure of SMI, this study builds on the definition developed by Kessler *et al.* (2005b, p. 618) as part of a recent analysis of the NCS-R data. The central measure of SMI used in this study involves any person with a 12 month diagnosis, as defined in the Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition (DSM-IV) who also exhibits one or more indicators of severity, specifically, any one of several conditions listed in Table 1.

Predictors were selected from the NCS-R study on the basis of both theory and previous research (see Hudson, 2005), as well as their availability for extraction in a parallel categorical form from the US Census STF3C database. Initial demographic predictors included age, gender, race, marital status, and region; socio-economic status indicators consisted of household income, education, and occupational status; and economic stress involved poverty status and employment. The NCS-R versions of these variables were coded using the categories reported in Table 2, and similarly, these categories were used in the preparation of the STF3C data.

Area-level data

Variables paralleling the foregoing were prepared from the 2000 US Census STF-3C long form data (see Table 2). This was initially done using both the state-level aggregation for the national as a whole as well as for Massachusetts using the counts from the zipcode level of aggregation. Whenever available, actual counts for the 18+ adult household population were used, however, in a few cases, the needed cross-tabulations were not included. In these instances, it was necessary to apply the appropriate proportion of adults in the household population to relevant sub-categories to obtain estimates. National totals excluded Alaska, Hawaii, Washington DC, and territories as these were not surveyed in the NCS-R study.

Validation data

Validation of the area-level estimates relied primarily on two types of indicators of SMI: (i) unduplicated rates of acute psychiatric hospitalization were computed from the Massachusetts Casemix data base for the years FY1994–FY2000 (MDHCFP, 1998). After aggregating the combined casemix files to the patient level, counts of patients were tabulated for each of the state's zipcodes, based on the patient's home address at first admission. A rate was then computed based on the size of the local population, divided by seven years, to obtain a fairly stable average annual rate. (ii) In addition, the STF-3C data also includes a question about the members of the household who the

Table 1 Definition of SMI used in this study

Any person with 12 month DSM-IV diagnosis is classified as having a SMI if one or more of the following conditions are met:

- There has been a suicide attempt, with serious intent and lethality, within the last 12 months.
- The individual has a work disability or a substantial work limitation due to a mental illness or substance abuse condition.
- The individual screens positive for a non-affective psychosis, e.g. schizophrenia, schizo-affective condition, etc.
- There is a diagnosis of Bipolar I or II.
- The person has a 12 month condition of substance dependence involving a serious role impairment.
- There is an impulse control disorder with repeated serious violence within the last 12 months.
- Or, there is any mental or substance abuse disorder resulting in 30 or more days absence from the usual role in the last 12 months.

Only adults 18 and over, living in the household population of the contiguous 48 US states, and who have sufficient fluency in English to participate in a household interview, are included in the sample.

Source: These definitions are adapted from those used in the study by Kessler *et al.* (2005, p. 618).

Table 2 Descriptive statistics on demographic and socio-economic predictors used in the study (*n* = 5493)

Predictor	*n*	Percentage	95% Confidence interval	SMI percentage
Gender				
Female	2870	47.7	45.6–49.8	5.4
Male	2620	52.3	50.2–54.4	5.3
Age				
18–29	1365	24.9	22.8–27.0	8.0
30–49	2181	39.7	37.4–42.1	5.9
50–64	1097	20.0	18.4–21.6	4.0
65+	849	15.5	13.8–17.3	1.4
Race				
White	4021	73.2	69.5–76.6	5.2
Black	669	12.2	10.3–13.3	5.8
Asian	86	1.6	1.1– 2.2	1.9
Hispanic	600	10.9	8.8–13.5	5.2
Other	116	2.1	1.6–2.8	12.8
Marital status				
Married	3134	57.1	54.6–59.5	3.6
Separated, widowed, divorced	1138	20.7	19.3–22.2	6.5
Never married	1221	22.2	20.1–24.5	8.7
Employment				
Employed	3645	66.4	64.3–68.4	4.1
Unemployed	227	4.1	3.3–5.1	3.5
Not in labor force	1619	29.5	27.7–31.4	8.4
Household income				
\$0 to \$14 999	828	15.1	13.1–17.3	9.4
\$15 000–\$34 999	1170	21.3	19.3–23.4	6.0
\$35 000–\$59 999	1207	22.0	20.5–23.6	5.5
\$60 000–\$99 999	1322	24.1	22.3–25.9	3.6
\$100 000 & over	966	17.6	15.2–20.2	3.3
Education				
No high school diploma	851	15.5	13.9–17.3	7.7
High school graduate	1804	32.8	30.6–35.1	6.2
Some college	1542	28.1	26.6–29.6	5.5
Bachelor's degree	724	13.2	12.0–14.4	2.4
Graduate education+	572	10.4	8.9–12.1	2.6
Occupational status				
Low (under 40)	1485	27.0	24.6–29.7	7.3
Medium (40–60)	2338	51.7	48.9–54.4	5.3
High (60+)	1170	21.3	19.8–22.8	2.9

Source: Computed from NCS-R long form data downloaded from the Interuniversity Consortium for Social and Economic Research website: http://www.icpsr.umich.edu/CPES/ (accessed October 2007).

respondent believes to be disabled due to a mental condition. Respondents are asked of each household member, 'Because of a physical, mental, or emotional condition lasting 6 months or more, does this person have any difficulty in doing any of the following activities? . . . a. Learning, remembering, or concentrating? . . . Yes/No'. Likewise, a rate was computed for each zipcode based on these reports. Preliminary research (Hudson, 2005) had shown that these indicators are strongly and positively correlated, and the totals for the Census indicators and the NCS-R estimates are in approximate agreement (5.2% versus 5.8%).

Modeling procedures

The estimation model was developed through the use of multiple logistic regression as implemented in the SurveyGLIM program, which is part of the LISREL 8.8 software package (Scientific Software, Inc., 2007), using the Bernoulli distribution and logit link function. This program has the advantage of not only producing correct standard errors, taking into account the complex sampling design of the NCS-R study, but also in its production of asymptotic variances and covariances needed for the computation of correct confidence intervals for the estimates.[1] The dichotomous dependent variable, 'SMI', was coded '1' if present and '0' if absent, and regressed on the predictors consisting of the demographic and socioeconomic variables previously outlined. In virtually all cases, the reference category for indicator comparisons was defined as that category hypothesized to be at highest risk, such as those with a high school education or with less than $15,000 annual income. This was recalculated with most of the non-significant predictors deleted, with the exception of income because of its theoretical significance based on previous research. The model was estimated both with and without an intercept included, but only that with the intercept was used. Diagnostic statistical indices examined included standard goodness-of-fit measures, residuals, a Receiver Operator Curve (ROC) analysis, as well as a classification table.

Estimation of rates

Estimation of the synthetic rates consisted of two stages. The first was the preparation of a parallel dataset, initially on Massachusetts zipcodes, using US census data. Variables with proportions of individuals within the same categories that were used in the initial modeling were computed. For, instance, five household income categories were used in the initial modeling (<$15K, $15–35K, $35–60K, $60–100K, and $100K+), so five variables were calculated from the Census counts with the proportion (from zero to one) of adults, 18+ and in the household population, in each of the same five income ranges. A SPSS 16.0 syntax program was then prepared to apply the regression weights to the corresponding proportions in the zipcode data set, and to calculate the logit estimates for each of Massachusetts' 499 populated zipcodes. The resulting logit values for each of the zipcodes were then converted into odds ratios and probability rates, giving the estimated SMI risk, which is used to estimate the proportion of the adult population that have a SMI. This procedure was repeated with data aggregated at the town/city (place) level for Massachusetts, as well as in a separate national data file, for the 48 contiguous US states, and finally, for the nation as a whole.

Whenever possible, confidence intervals were computed for the estimated rates using SPSS syntax. This was done in two stages. First, asymptotic standard errors (ASEs) were computed for each area logit estimate using an adaptation of the formula that was initially developed by Collett (1991, p. 88), and later refined by Sofroniou and Hutcheson (2002, p. 11).[2]

Validation of model

The model estimates were examined for internal consistency, face validity, and predictive validity. Internal consistency was assessed through a comparison of rates of SMI estimated by the model with those directly calculated from the NCS-R dataset. An initial SMI model produced an estimate of 3.89% which was decidedly less than the 5.35% that was estimated directly from the dataset. Examination of the two data files and the means of the various predictors revealed that this was almost certainly a result

1. Descriptive statistics and their associated confidence intervals that were not available in the SurveyGLIM program were computed using the Complex Samples module, which is part of the SPSS 16.0 statistical package.

2. The formula used in these calculations is the following:

$$ASEofLogit(p) = \sqrt{\left[\sum_{j=1}^{k} x_{j0}^{2} Var\left(\hat{\beta}_j\right) + 2\sum_{j=1}^{k}\sum_{h=1}^{j} x_{h0} x_{j0} Cov\left(\hat{\beta}_h, \hat{\beta}_j\right)\right] \Big/ n}$$

These calculations were done with values derived from the matrix of asymptotic variances and covariances produced by LISREL's SurveyGLIM module, which take into account the complex sample design of the NCS-R study. Sofroniou and Hucheson's formula for single case estimates was adapted using the standard formula for computing standard errors for binomial data for samples, rather than individuals (Loether and McTavish, 1980, p. 472), with the sample size (n) defined in this study as the actual number of individuals in each area that were interviewed using as part of the long-form US Census (approximately one-fifth of the population). The ASEs were then converted to standard errors for odds ratios, and finally into ASEs for probabilities. Confidence intervals computed using these ASEs for the sample probabilities and these were evaluated through computing the proportion of the Census family reports of mental illness that fell within the confidence intervals. Based on this assessment, these confidence intervals are reported for towns and cities in Massachusetts, but they proved too restrictive or unreliable for the larger states or the nation as a whole, and thus are not reported in this article.

Table 3 Selected measures of prevalence of mental illness in adults in the household US population (n = 5493)

	n	Percentage	95% Confidence interval
Any lifetime diagnosis	2648	46.5	44.3–48.7
Any 12 month disorder	1442	25.3	23.7–27.1
Serious mental illness	394	5.3	4.8–5.9
Serious and persistent mental illness (current and >two years)	264	4.8	4.3–5.4
Serious and persistent mental illness, with no insurance	50	0.9	0.7–1.2

Source: These are directly estimated rates from the NCS-R long form data downloaded from the Interuniversity Consortium for Social and Economic Research website: http://www.icpsr.umich.edu/CPES/ (accessed October 2007).

of two factors: a less severe distribution of socio-economic conditions in the census as compared with the NCS-R random sample, as well as an anomalous result of the modeling process, which resulted in an estimate of a negative intercept, contradicting the known, but very unusual, occurrence of SMI under even the most favorable conditions. Thus, it was decided to constrain the model by adding a correction constant to the intercept that would result in a non-zero and positive intercept, thereby prohibiting any negative rates from being computed. This constant would also need to be consistent with a national total comparable to the surveyed total of 5.35% based on that directly estimated from the NCS-R data. With the aid of an Excel spreadsheet, a corrected logit intercept was estimated to be 0.090 and was then used to substitute for the initially estimated intercept of –0.278. This corrected intercept resulted in a new national estimate of 5.49%, well within the 95% confidence interval of the 5.35% that is directly estimated from the NCS-R survey data.

The most important validity analysis consisted of an examination of the relationship between the model's projected rates and independent indicators, specifically family reports from the US Census about mental disability in one or more of their members, and in Massachusetts, acute psychiatric hospitalization rates, both overall, and for a few selected diagnosis such as schizophrenia and bipolar condition. Means were examined, but the most important assessment of these relationships was conducted through computation of Pearson r correlations, as well as linear regressions and their scatterplots. Analyses of subgroups were conducted for both zipcodes and towns within five quintiles of population size.

Results

Rates of SMI

This study shows that approximately 5.5% of the adult household population in the United States, currently or in the previous 12 months, has been disabled by a SMI (Table 3). The SMI rate in this study is very similar to the 5.8% rate that Kessler *et al.* (2004) computed, since virtually the same data is used.[3] This 5.5% represents over a fifth of the 25.3% of the adult population who have recently experienced most of the common mental disorders recognized by the American Psychiatric Association (listed in the DSM-IV manual), and close to a ninth of the 46.5% of the population who have such a disorder at some point in their lives. Because some state mental health authorities are mandated to serve only those seriously and persistently mentally ill persons who have no financial resources for their care, involving either private or public forms of health insurance, the percentage of the population who would meet such criteria was also computed, and this figure is 0.9% (95% confidence interval = 0.7–1.2).

Descriptive data on demographic and socio-economic predictors

The population from which the sample was drawn for this study is the US adult household population. Thus, the sample encompasses most major demographic groups. The predictors were selected based on those known from previous studies to be associated with rates of SMI, as well as ones that are available both in the NCS-R and the US Census STF-3 datasets, and capable of being recoded into identical categories (see Table 2). Each of the sets of unadjusted rates reveal dramatically elevated rates of SMI in the most marginalized groups. Young adults experience elevated rates of SMI, at 8.0%, compared with 1.4%, among those over 65. Although Whites, Blacks, and

3. However, the data on the obsessive-compulsive disorder could not be included in the current study due to reliability problems reported by the original researchers, thus, this difference is believed to account for the slightly lower rates found in this study.

Hispanics experience roughly comparable rates, in the 5.3% to 5.8% range, Asians have a reduced rate, at 1.9%, in contrast to those with other or multiple racial identifications who have the highest rate at 12.8%. The never married are also at considerable risk, at 8.7%, compared with those married with a risk of 3.6%. Groups with varying levels of socio-economic status, involving income, education, and occupational status, also experience consistent differentials in risk of mental breakdown the expected direction, ranging from 2.6% for the most privileged to 9.4% for the most disenfranchised.

Predictive model

The occurrence of a SMI disorder among the NCS-R respondents was regressed, using the multiple logistic regression procedure, on the full set of the study's demographic and socio-economic predictors (Tables 2 and 4). This analysis resulted in a highly significant model (Wald chi-square = 616.917; df = 21; $p = 0.000000$) in which most of the predictors were individually significant (Table 4). Persons in the 50 to 64 and the 65-plus age categories had dramatically reduced risks of SMI, with odds ratios at 0.46 and 0.08, respectively. Whites, Blacks, and Hispanics all had dramatically lower rates than those with mixed racial identifications. Although married persons had only three-fifths (0.61) the risk as the never married, those separated, widowed, and divorced had an elevated risk, at 1.21, compared with the never married.

Risk was dramatically reduced for those with favorable socio-economic characteristics. Those with the highest level of education, involving at least some graduate work, had almost half the risk of SMI (0.506), compared with those who did not complete high school. Although the regression weights for higher income groups were reduced, these did not prove to be significant, possibly because of the simultaneous controls for education, occupational status, and employment. Nonetheless, it was decided to retain income in the model due to its theoretical significance as supported by previous research.

Because the intended use of this model is primarily for estimation purposes, rather than for testing a particular theory, it was decided that the most appropriate means of initial model assessment is through a cross-tabulation analysis of its predictions for the individuals in the NCS-R sample compared with their actual classification using the data from that sample. Table 5 shows that overall 91.1% of its predictions are correct. However, the reader should not be misled by this high number, since it is not difficult to make correct predictions for the 95% of the population who *do not* have a SMI. In fact, the model demonstrated a specificity of 95.1%, involving correct predictions of the non-occurrence of SMI in this population. In contrast, the model has a modest specificity of 21.1% in correctly predicting the occurrence of SMI among those who actually have such a condition. Although this proportion is considerably greater than what could be expected by chance, and provides very useful information for overall population estimation purposes, it falls considerably short of a model that could be used for individuals for clinical or diagnostic purposes. A ROC was also examined, and this revealed a moderate level of discriminate validity with an area under the curve (AUC) value of 0.74 (95% confidence interval = 0.71–0.76). The model generates risk scores for the NCS-R respondents that range from 0.1% to 46.6%, with mean of 5.3%, and standard deviation of 5.1%.

The estimates and their validation

The adjusted logit weights from the logistic model, described earlier, were used to compute estimates for several types of localities that were then compared with independently collected indicators of SMI. This was done by using a SPSS syntax program to substitute the values for each of the original NCS-R predictors with the parallel Census values for the various areas examined, then summing to produce an area logit value. Finally, these logit values were converted into a probability or proportion for each area. This was done initially at the national level to compare the predicted rate of 5.5% for the 48 states with the directly estimated SMI rate of 5.3%, or Kessler's 5.8% rate, all within the 95% confidence interval for the directly estimated rate. The predicted 5.5% was only about 0.11 more than that derived from what families reported to the US Census enumerators in 2000, or 4.94% (see Table 5).

The next set of predictions involved the 48 states. Sample rates for the states with the highest and the lowest rates are reported in Table 5. These range from a low of 4.73% for Maryland to a high of 6.97% for West Virginia. Those with the lowest rates are concentrated in the area between Virginia and Massachusetts, as well as Florida and California, whereas the states with the highest rates are found mainly in the Appalachian and lower Mississippi valley regions, ranging from West Virginia to Louisiana and Mississippi. Many of the sparsely populated and relatively isolated western states also had relatively high rates (see Figure 1). These estimated rates are remarkably close to those calculated from the Census family reports, specifically, the mean absolute difference between the two sets of rates is 0.8%, which represents

Table 4 Multiple logistic model of rates of SMI, regressed on demographic and socio-economic predictors ($n = 5493$)

Predictor	*B*	Standard error	*p*	Exp (*B*)	Exp (*B*) 95% confidence interval
Intercept	−0.277	0.271	0.307	0.758	0.64–1.86
Age					
18–29: reference					
30–49	−0.051	0.171	0.766	0.950	0.68–1.34
50–64	−0.777	0.219	0.000	0.459	0.30–0.71
65 plus	−2.596	0.322	0.000	0.077	0.04–0.14
Race					
White	−0.549	0.259	0.034	0.577	0.35–0.96
Black	−0.968	0.275	0.000	0.380	0.22–0.65
Asian	−0.594	0.927	0.085	0.203	0.03–1.25
Hispanic	−0.976	0.279	0.001	0.377	0.22–0.65
Other: reference					
Marital status					
Married	−0.495	0.187	0.008	0.610	0.42–0.88
Separated, widowed, divorced	0.190	0.174	0.274	1.210	0.86–1.70
Never married: reference					
Employment					
Employed	−1.075	0.106	0.000	0.341	0.28–0.42
Unemployed	−0.682	0.321	0.034	0.506	0.27–0.95
Not in labor force: Reference					
Household income					
\$0–\$14 999: reference					
\$15 000–\$34 999	−0.131	0.154	0.393	0.877	0.65–1.19
\$35 000–\$59 999	−0.096	0.193	0.618	0.908	0.62–1.33
\$60 000–\$99 999	−0.304	0.163	0.062	0.738	0.54–1.02
\$100 000 & Over	−0.406	0.291	0.162	0.666	0.38–1.18
Education					
No high school diploma: reference					
High school graduate	−0.233	0.159	0.143	0.792	0.58–1.08
Some college	−0.283	0.187	0.131	0.754	0.52–1.09
Bachelor's degree	−0.916	0.267	0.001	0.400	0.24–0.67
Graduate education+	−0.681	0.303	0.025	0.506	0.28–0.92
Occupational status					
Low (under 40): reference					
Medium (40–60)	−0.263	0.133	0.048	0.769	0.59–1.00
High (60+)	−0.506	0.236	0.033	0.603	0.38–0.96

Source: Computed from NCS-R long form data downloaded from the Interuniversity Consortium for Social and Economic Research website: http://www.icpsr.umich.edu/CPES/ (accessed October 2007).
Note: Adjusted Wald $F = 15.388$ (df = 21, 22; $p = 0.000000$); Wald chi-square = 616.917 (df = 21; $p = 0.000000$). The model's sensitivity is 21.1%; its specificity, 95.1%; and overall predictability, 91.1%. A corrected intercept of 0.090 is used in calculation of synthetic estimates. See Methodology section for details.

Table 5 Selected estimates of SMI for the United States and selected localities

Geographic units	Rank	Percentage (95% confidence interval)	Census MH disability rate
United States			
(48 in aggregate)	—	5.49	4.94
Individual US states			
Lowest rates			
Maryland	1.5	4.73	4.14
New Jersey	1.5	4.73	3.98
Connecticut	3	4.77	4.22
Massachusetts	4	4.98	4.62
Florida	5	5.10	5.16
Highest rates			
Louisiana	44	6.27	6.04
Mississippi	45	6.35	7.06
Oklahoma	46	6.44	5.93
Kentucky	47	6.79	7.31
West Virginia	48	6.97	8.20
Massachusetts towns and cities			
Lowest rates			
Waban	3*	2.33 (0–7.7**)	1.06
Lexington	4	2.43 (0.1–4.8)	3.11
Lincoln	5	2.44 (0–8.6)	2.09
Newton Highlands	6	2.47 (0–7.4)	2.63
Weston	7	2.54 (0–6.6)	2.07
Highest rates			
Fall River	420	7.42 (6.1–8.8)	7.18
Indian Orchard	421	7.73 (2.8–12.6)	8.66
New Bedford	422	7.75 (6.5–9.1)	7.71
Lawrence	423	7.86 (6.3–9.4)	7.41
Chelsea	424	7.97 (5.6–10.3)	7.47

14% of the projected rates. These differences ranged from a low of 0.03% in Maine to a maximal difference of 2.6% in Nevada.

Finally, rates were calculated for local areas for a sample state, Massachusetts. Unlike many states, census places in Massachusetts, more commonly known as towns and cities, cover the entire land mass and do not leave out intervening rural areas (Table 5). These areas have a mean population size of 14 974, with a standard deviation of 25 699 ($n = 424$). The rates of SMI range from 2.33% in the small wealthy town of Waban in the western suburbs of Boston, to 7.97% in Chelsea, a working-class community in the inner part of the Boston metropolitan area. These rates were also fairly close to those derived from the Census family reports, which similarly ranged from 1.06% in Waban to 7.47% in Chelsea. The absolute deviation between the two sets of rates had a mean of 0.95% and a median of 0.73%.

Massachusetts towns with population sizes in the lowest quintile or fifth of towns with fewer than 2335 persons were excluded from Table 6 and the foregoing analysis since estimates for such small populations proved unreliable. This was determined from bivariate regressions and linear correlations between the estimates and the Census reports, for both states and Massachusetts towns and cities (see Figure 2). In these, the project estimates are plotted against the Census reports, for both the states as a whole, and the five groups of Massachusetts towns. These illustrate the linear relationships between the two sets of figures for both the states and the upper four quintiles of towns, with R^2 figures ranging from 0.33 to 0.61, indicating moderate to strong correlations for all

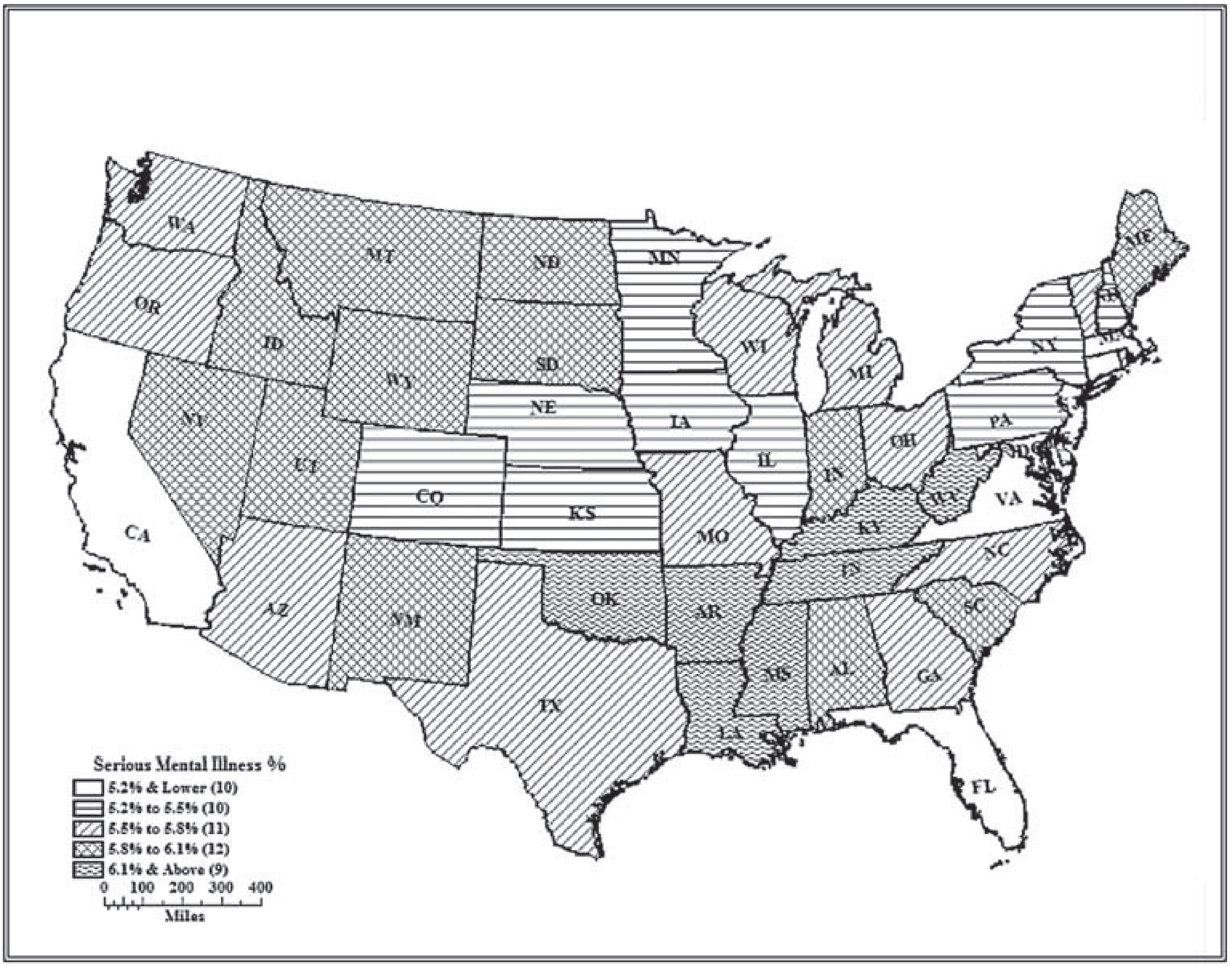

Figure 1 Rates of SMI in the contiguous 48 US states.

these types of towns and states. However, the final scatterplot for the lowest quintile, those Massachusetts small towns, those with fewer than 2335 persons, showed a complete absence of a relationship, with a R^2 at 0.0014, a finding that is fully consistent with the expected instability of estimates in the smallest area, and which provides a lower population limit for the applicability of this model. It is for this reason that these small towns are excluded from the analyses discussed earlier.

The assessment of the predictive validity of the estimates was also based on several correlation coefficients (see Table 6). Both for the 48 states and for Massachusetts towns and cities, the Pearson correlation between the two sets of SMI estimates were quite strong, at 0.72 and 0.75 (p < 0.000), and almost as strong, at 0.68 (p < 0.000) for the smaller zipcodes. In addition, the SMI rates were correlated with a another set of SMI indicators, average annual rates of acute psychiatric hospitalization for the 1994–2000 period, based on unduplicated counts of such individuals, allocated to their home zipcode and corresponding town or city. These correlations ranged from a low of 0.43 (p < 0.000) for hospitalization rates for persons with the diagnosis of bipolar condition, to 0.58 (p < 0.000) for all diagnoses among the various zipcodes.

One additional analysis was conducted on the adequacy of the procedures used for estimation of confidence intervals for the SMI rates. This involved the calculation of the proportion of rates for the Census family reports that fell within the bounds of the computed 95% confidence intervals. Whereas 95.3% of the Census family reports came within the expected intervals for towns and cities, 97.7% of those for the zipcodes fell within the

Table 6 Validity coefficients for SMI rate estimates, for US states and Massachusetts local areas

Areas	*N*	Correlation (*r*)	Probability
US States[1]			
2000 Census indicator of mental disability	48	0.72	0.000
Massachusetts towns and cities[2]			
2000 Census indicator of mental disability	418	0.75	0.000
Overall acute psychiatric hospitalization rate	418	0.53	0.000
Rate of acute psychiatric hospitalization for schizophrenia	418	0.51	0.000
Rate of acute psychiatric hospitalization for bipolar conditions	418	0.43	0.000
Massachusetts zipcodes[2]			
2000 Census indicator of mental disability	399	0.68	0.000
Overall acute psychiatric hospitalization rate	399	0.58	0.000
Rate of acute psychiatric hospitalization for schizophrenia	399	0.51	0.000
Rate of acute psychiatric hospitalization for bipolar conditions	399	0.53	0.000

[1] Excludes Alaska and Hawaii, as NCS-R data is not representative of these states.
[2] Excludes areas in the first quintile of population size, under 2335 for towns and cities, and under 2449 for zipcodes due to unreliability of model in small areas.

expected ranges. However, only 11.5% of those for states came within the range (which had mean lower and upper confidence intervals of 5.44% and 5.90%). This probably results from the very large population sizes that result in overly optimistic or restrictive confidence intervals, and for these reason, these confidence intervals are not reported in Table 5 because of their apparent lack of reliability.

Discussion

This study demonstrates dramatic variations in the rates of SMI, not only between individuals, but between local areas. But perhaps more important, it demonstrates the feasibility of using the results from national surveys, such as the NCS-R, for local area estimation of psychiatric and social problems, and thus, for needs assessments. These disparities in SMI rates, far from random, represent the systematic impact of low socio-economic status and social marginalization in placing both communities and individuals at substantial risk of SMIs. The overall rates calculated in this study, with a mean of 5.5% for the adult population, are consistent with the most recent national estimates that range from 3% to 7%. These averages mask the fact that the greatest variations in risk are at the individual (0.01% to 47.0%) and small area levels (2.3% to 7.9%), and fairly modest at the state level (4.7% to 7.0%), most likely due to their larger populations. This highlights the importance of individualizing service planning not only for individuals, but for particular communities.

It should be noted that this study, unlike previous ones, has not attempted to shed further light on the perennial theoretical questions involving social causation or social selection, since the task of prediction and estimation is largely unaffected by the resolution of these important questions. However, the model developed for this project clearly is consistent with previous studies that document the iatrogenic impact of unfavorable demographic and socio-economic conditions. A recent study, based on some of the same data used here, has shown negligible downward socio-economic and geographic drift subsequent to initial psychiatric hospitalization (Hudson, 2005). A few departures from previous research, however, should be noted. Although the impact of education and occupational status were in the expected direction and significant, the impact of income in the final model selected was not statistically significant, although it was strong and in the expected direction. This is most likely due to the statistical controls for education and occupational status, two key determinants of income. The impact of age, with SMI rates declining with age, was much more dramatic than expected based on prior research. This pattern undoubtedly represents a combination of effects, such as a lower level of long-term chronicity than has been the traditional expectation for this population (Harding, 1995), as well as high rates of premature death among many of the seriously mentally ill.

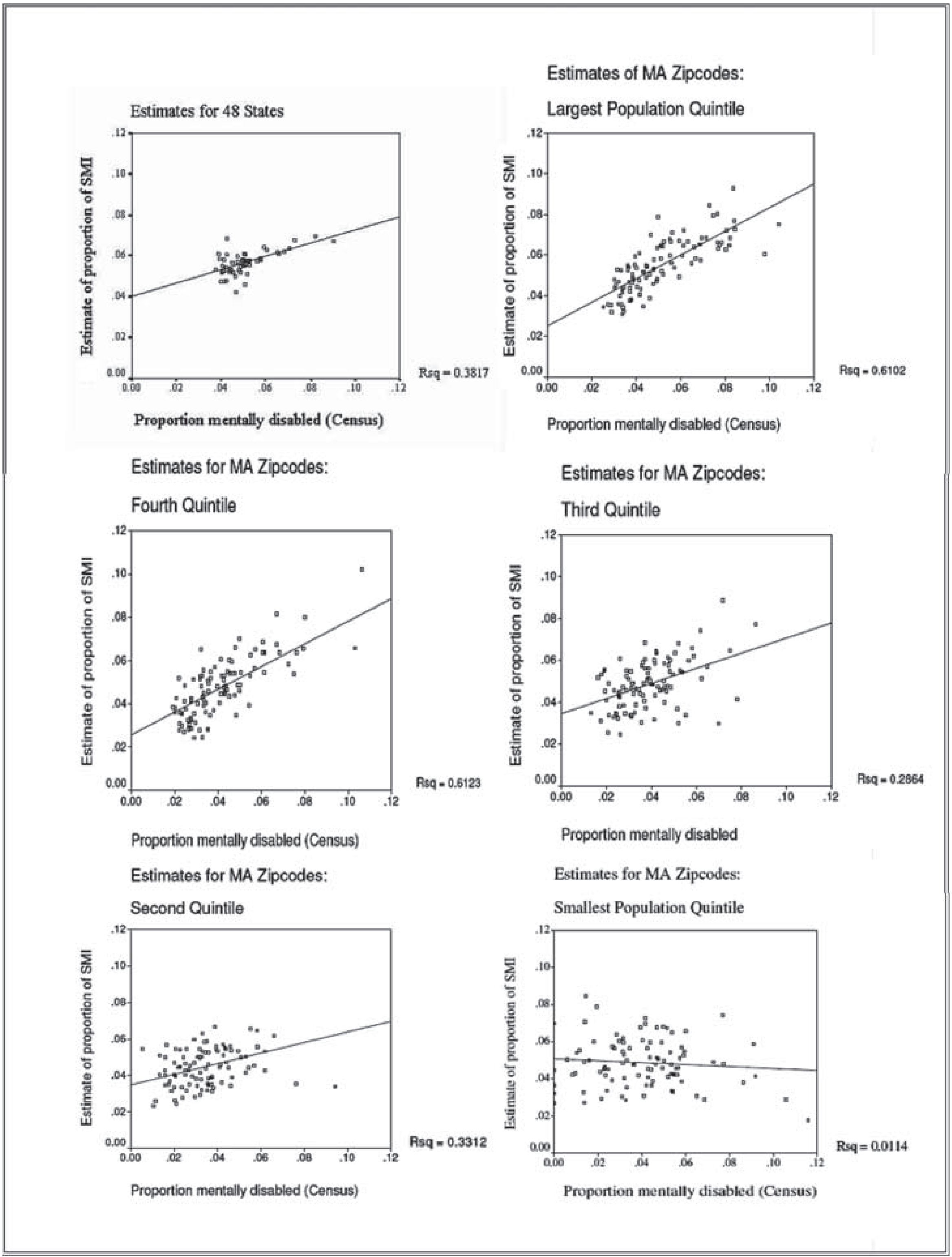

Figure 2 Bivariate regression of SMI estimates on Census mental disability indicator for states and Massachusetts zipcode population quintiles.

The state and local SMI estimates computed, based on the project's model, show very strong validity in these initial assessments. They demonstrate both strong agreement and correlation with independently obtained estimates, on the zipcode, town and city, state, and national levels, with a few important exceptions. They are not valid for very small towns or zipcodes, those with fewer than 2335 persons. However, this may not be a serious limitation, not only because rates on such small areas are infrequently needed, but also because it is practical to consolidate small areas into aggregated areas using standard geographic information systems techniques. In any case, most mental health catchment areas tend to be considerably larger. The inferential statistical techniques used in this study to generate confidence intervals, and in general, those required for small area estimation projects, have not been fully developed or tested, and for this reason, confidence intervals are not reported for states in this study, unlike towns and communities, because of their apparent unreliability *vis-à-vis* the indicators examined.

Although this study has produced strong initial support for the validity of the estimates produced and modeling procedures used, its limitations highlight the need for continued research. The model needs to be validated with data from parallel yet independent community surveys using standardized instruments, at least in selected localities. Of great importance, is the continued testing and development of techniques for simultaneously incorporating estimates of both measurement and sampling error into the complex algorithms used to compute the SMI rates, and in the subsequent estimation of rates for individual entities and their aggregation to populations.

The procedures used in this study have drawn on extensive work in recent years mostly outside of the mental health field. However, this work remains experimental and vulnerable to several methodological limitations. The associated inferential techniques have not been fully validated and incorporated into available statistical packages. Thus, the standard errors of the individual estimates probably do not fully incorporate the measurement and sampling error introduced at several stages. In addition, one cannot assume that the same predictors exist at both the individual and area levels. However, extensive research on the part of this researcher, as well as many others, has demonstrated that most of the same socioeconomic and demographic predictors of SMI are valid on both the individual and community levels (see Hudson, 2005).

Needs assessments typically require prevalence estimates, but they also require much more. They require detailed profiles of local populations in need, e.g. their demographics, history, diagnostic profile, comorbidities, service usage, service barriers, opportunities, and strengths, etc. The procedure used in this study can also be used to estimates rates of more specific diagnostic and demographic groups. Needs assessments also require the identification of service models, best practices, especially evidence-based practices and the like, current service efforts, as well as analyses of costs of current and proposed services and client preferences. Estimation of prevalence is only one component, albeit an important one, in the enterprise of needs assessment.

Notwithstanding these caveats, the results of this project are expected to have applications in several areas. National and local mental health authorities often struggle to find meaningful ways to identify geographic areas of greatest need, and often rely on previous service utilization patterns, total population, and fall back on the pushes and pulls of politicians and local grant seekers. Few would deny that a central element in resource allocation should be demonstrated need. Rates estimated on the basis of studies such as the National Comorbidity Study, with its demonstrated reliability and generalizability, provide an inexpensive and credible data source for the assessment of many types of need. Policy researchers and program evaluators often struggle to make meaningful comparisons between systems and agencies as to effectiveness and impact, but are unable to do this without the ability to make adjustments for the differential case and problem mix in the targeted communities, and for this purpose prevalence rates provide an invaluable basis for such adjustments. SMI prevalence rates also have implications for the deployment of specific service modalities within service agencies, such as assertive case management, clubhouses, and psychiatric rehabilitation, as well as the development of strategies to assure service access. Because the multiple needs of seriously mentally ill persons are as great as they are, it is of critical importance that resource allocation and service planning be as cost effective, efficient, and empirically informed as possible.

Declaration of interest statement

The author has no conflict of interest.

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