Work Organization, Area Labor-market Characteristics, and Depression among U.S. Nursing Home Workers:

A Cross-classified Multilevel Analysis

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Associations between forms of work organization that follow globalization and depression were examined in U.S. nursing home assistants. A cross-sectional study of 539 nurse assistants in 49 nursing homes in three states in 2000 assessed nursing home ownership type, managerial style, wage policy, nurse assistants' emotional stresses, and area labor-market characteristics (county income inequality, median household income, and social capital) in relation to the prevalence of depression among the nurse assistants. A cross-classified multilevel analysis was used. For-profit ownership, emotional strain, managerial pressure, and lack of seniority pay increases were associated with depression. Labor-market characteristics were not associated with depression once work organization was taken into account. The deregulation of the nursing home industry that accompanies globalization is likely to adversely affect the mental health of nursing home assistants. *Key words*: nurse assistants; work organization; depression; nursing homes; multilevel analysis; labor market.

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Depression figures prominently among the hazards of unfavorable work organization.[1] Depression in the workplace, including both symptoms of depression and full-blown syndromes, has important consequences for workers' quality of life, the costs and utilization of health care, and workplace productivity.[2–4] various investigations have demonstrated relationships between work organization (in particular heavy job demands and lack of autonomy) and depression,[1,5–9] as well as providing longitudinal evidence linking job demands, lack of autonomy, and other elements of work organization with depression.[10–13] Overall, these investigations of work organization and depression constitute a body of analytic epidemiology that supports the development of preventive interventions in the workplace,[14,15] because specific, potentially malleable organizational risk factors are readily identifiable.

Nursing homes rank among the lowest-paid industries in the United States for direct-care employees such as nurse assistants (NAs). The approximately 700,000 NAs in nursing homes earn salaries that are often barely above the minimum wage.[16] In addition, NAs are subject to multiple emotional demands, which include may attachment to sick and terminal clients and needing to provide emotional support to cognitively impaired elderly.[17–19] In spite of the size of the NA workforce,[20] few studies have examined the association between work organization and mental health of NAs in nursing homes. There is some evidence suggesting that unfavorable nursing home work organization may have an important effect on NAs' depression.[21] For example "stress" has been empirically linked to features of work organization among NAs.[22–24] Some studies have found associations between work organization in long-term care facilities (i.e., management-related interpersonal stressors, heavy workload, low autonomy on the job) and general mental health.[23,25,26] In addition to work organization itself, structural attributes of work organization (e.g., ownership type, worker–management relations, and low wages) are likely to affect NAs' health.[17,27,28] For example, the shift towards investor-owned managed care organizations and privatization that characterizes globalization in health services29,30 has been associated with increased workloads among nursing home workers.[31]

The globalization of human services is one of the most important current developments in the econ-

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omy.[29] The expansion of nursing home multinational corporations is part of this new development. For example, the largest nursing home providers in the United States have acquired a sizeable number of facilities abroad, including homes in the United Kingdom, Spain, Germany, and Australia.[20] These enterprises command large sums of public funds but often are not accountable for quality and expenditures, and have been associated with high rates of quality-of-care deficiencies (e.g., failure to properly treat pressure sores, manage pain, manage loss of weight.[20,32,33] The effects of such organizational factors on the health of nursing home workers remain, however, largely unexplored.[34]

In addition to work organization, economic characteristics of NAs' labor market areas may be associated with depression. In addition to the work-environment consequences of the privatization of health services, globalization could also affect the health of low-income health care workers via its effects on local labor markets. Studies of the health effects of residential area social characteristics have found that area (region, state, metropolitan area) income inequality is associated with depression.[35–38,39] The relevance of these two factors with respect to NAs' health is suggested by the observation that both work organization[40] and economic inequality[41] effects are stronger in workers in low-income occupations, such as nurse assistants.

The present study aimed at determining the strength of the association between organizational and labor-market factors and depression among NAs, who are engaged in an important healthcare occupation. Building on previous research on multilevel analyses of area[42] and the workplace,[43] we explored these contextual associations simultaneously using a cross-classified two-level model.[44] Evidence for the effects of work organization on nursing home workers' mental health could support the need for regulating nursing homes,[45] including adjustments to workplace health and safety standards (e.g., adequate workloads), increased inspections, or other changes in the organization of work to ensure worker well-being.

METHODS

Sample and Setting

A cross-sectional design was used. Data were collected from 539 NAs working in the 49 unionized nursing homes in the 56 counties of West Virginia, Ohio, and Kentucky by a single union over an eight-month period between October 1999 and June 2000. Nursing homes' site-specific lists were obtained from the local bargaining unit representatives, and all NAs currently working at each nursing home ($n = 896$) were invited to participate. The overall response rate was 60.2%. Sixty-six questionnaires were not used due to a high rate of blank responses or damaged hard copies. Thus, 473 questionnaires were evaluated as valid to use in the data analyses. A random sample of non-respondents ($n = 32$) was approached and interviewed over the telephone (93% response rate). Non-respondents to the mail survey reported more hours of housework per week than did respondents to the mail survey. Non-response was not associated with nursing home characteristics.

Variables

Depression. Depression was measured using a 35-item version of the RCES-D.[46] As the original version of the CES-D fails to capture important aspects of the domain of depression (psychomotor retardation/agitation, suicidal ideation) and represents depression using symptoms that are not aspects of the current DSM criteria, the 35-item RCES-D was used to dichotomously define a depressive disorder. This involved classifying symptoms into subscales and matching the subscale scores to the criteria for depressive disorder in the DSM-IV (details available upon request). Items were summed and empirically dichotomized so that the lower two thirds of scores for each subscale represented the reference group. The proportion of respondents presenting scores above the traditional 16+ cutoff score indicating risk of depression were lower for the revised scale than for the original CESD scale (48.5% vs 54.2%).

Work organization. Emotional demands were assessed with a six-item scale.[43,47] These items are designed to capture the workplace emotional demands experienced as a result of providing direct care to clients (e.g., not enough time to provide emotional support to clients). Two sources of data, one secondary and one primary, were integrated into an organizational-characteristics database and linked to individual NAs' records using nursing home as the linkage variable. The Nursing Home Compare Database based on the Center for Medicare and Medicaid Services (CMMS) On-Line Survey Certification of Automated Records and Minimum Data Set (CMMS, 2000) provided type of ownership (for-profit vs. not-for-profit). We also administered the organizational survey, using an adaptation of a questionnaire used in a previous study of human services organizations,[43] to key informants in each nursing home during the data-collection period. Questions asked about presence in the nursing home of a bureaucratic management style (i.e., "by the book"), labor relations violations, perceptions of labor–management conflict, and seniority-based wage increases. These three indicators were combined into a single additive scale "managerial pressure" indicator. All organizational-level variables were operationalized as categories for the multivariate analyses.

Economic inequality. The income inequality of the county of residence for each respondent was obtained with the Gini Index from the University of North Car-

olina at Chapel Hill, based on the U.S. 1990 Census.[48] The median household income for the county of residence was obtained directly from the U.S. 2000 Census.[49] We used as an indicator of communitarian social capital the most supported presidential candidate in the 2000 presidential returns (Gore or Bush). The Democratic campaign and the previous administration have been using the social capital idea consistently as a framework,[50,51] including a book that made explicit mention of the construct by the candidate.[52] The presidential election returns in 2000 for each county were obtained from the *World Almanac & Book of Facts, 2002.* A dichotomous indicator was obtained from these raw data indicating presence or absence of social capital.

Potential confounders. We also assessed demographic, psychosocial, behavioral, health, and labor–market related potential confounders. These included age of respondent (continuous), gender of respondent (male, female), race/ethnicity (white, black, Hispanic, Native American, and other), health insurance (availability as well as type), and length of employment at that nursing home measured in months. Social support was measured with marital status (married, cohabitating, separated, divorced, and single/never married) and weekly hours of housework. A question identified the type of unit (i.e., subacute, Medicare/skilled nursing, standard/basic nursing, Alzheimer's, rehabilitation, other) where the NA worked. Measures of social stratification included education (in years as well as highest degree held) using the question: "What is the highest grade in school or year of college that you completed?") and income (determined with two questions on total annual personal and household income). These indicators were adapted from the National Comorbidity Survey.[53] Indicators that were not determined to be confounders were not included in the reported analyses.

Data Analysis

Data analyses were conducted in sequential steps, including linkage, exploratory data analyses, and multilevel analyses. Multilevel models were used because the measurement of NAs' depression within nursing homes has a hierarchical structure.[43] Multilevel models take into account this natural clustering, allow the impact of individual level variables on substance use to vary across nursing homes, and use organizational-level variables to explain the difference in individuals' baseline risks and the differential impact of individual-level variables on substance use. A statistical software package MlwiN[44] was used to implement the model, in which iterative generalized least-squares (IGLS) was used to find maximum-likelihood estimates of the parameters for binary outcomes. We performed regression diagnostics to determine the precision of our estimates.[44] The model was built in stages, starting from a simple variance-components model, and successively adding to the model the fixed effects and random effects for the variables of interest at different levels. One particular feature of the multilevel models used in our data analyses is that all the two-level models were cross-classified, given there are two contexts above the level one of NAs, namely the location of the nursing home and the county of residency. The NAs reside in different counties and work in different nursing homes, and the nursing home in which a NA works may or may not be within the same county where he or she resides. MLWin allowed us to implement a cross-classified two-level model for the analysis of our data. Ignoring the cross-classification effect would make the hierarchical structure incomplete, consequently affecting the estimation of standard errors of regression coefficients. Correct standard errors would be estimated only if variation at all contexts level were allowed for in the analysis.

We had 473 valid questionnaires, but in MLwiN analysis were conducted with data from 346 respondents. The reason was that in order to build cross-classification model, we need a three-level identifier: NA ID, nursing-home ID, and county ID. MLwiN does not allow any missing IDs. So after constructing the cross-classification model, data for any subject who had not provided either nursing home ID or county ID were eliminated from the multilevel analysis. Analyses of these missing participants in non-multilevel analysis did not reveal sociodemographic differences between them and those included in the multilevel analysis. The model building started from the variance-components model with random intercept only, then successively added fixed and random effects for the variables of interest to improve model fit and to reduce the random-effect variation. Diagnostic procedures were explored to the final model at both levels, including testing model assumptions, detecting outliers, determining precision of our parameter estimates, and influence points on model fit. Appendix B illustrates how we built up our mixed-effects two-level model and cross-classification model.

RESULTS

Descriptive statistics for selected variables in the sample are presented in Table 1. The NAs were mostly women, less than 45 years old, with high school education, white non-Hispanic, with low household incomes, working in for-profit nursing homes, and did not receive seniority wage increases. Approximately half of them were married, and half self-reported good health but presented symptoms of major depressive disorder.

Table 2 lists the regression estimates for the four nested cross-classified two-level models. The variance-components model (cross-classified) was examined first with random intercepts only, then successively adding fixed and random effects for the variables of interest to improve model fit and to reduce the random-effect variation. The definition of the variables

TABLE 1 Sample Description

	No.	%
Individual		
Age		
Less than 45	308	65.1
45 and over	165	34.9
Gender		
Female	473	100.0
Male	0	0.0
Marital status		
Married first time	175	37.6
Married with previous marriage	48	10.3
Divorce/separated	93	20.0
Widowed	19	4.1
Never married	104	22.3
Living as if married	27	5.8
Education		
Elementary school	3	.7
Junior school	19	4.2
High school	333	73.0
Junior college or 1–2 years college	64	14.0
College graduate	14	3.1
Graduate school	23	5.0
Hispanic		
Yes	7	1.6
No	441	98.4
Race		
American Indian or Alaska native	5	1.1
Asian	0	0.0
Black or African American	56	12.2
Native Hawaiian or other Pacific Islander	0	0.0
White	399	86.7
Overall health		
Excellent	37	7.9
Very good	113	24.2
Overall health (*continued*)		
Good	203	43.5
Fair	97	20.8
Poor	17	3.6
Household income for past year		
≤ $10,000	43	13.7
≤ $15,000	52	16.6
≤ $20,000	46	14.6
≤ $25,000	58	18.5
≤ $35,000	51	16.2
≤ $50,000	34	10.8
≤ $60,000	18	5.7
≤ $75,000	7	2.2
≤ $75,000	5	1.6
Organizational		
Ownership type		
For profit	309	70.1
Nonprofit	132	29.9
Seniority wage increase		
Yes	109	27.7
No	284	72.3
Managerial pressure		
Yes	254	81.4
No	58	18.6
Depressive disorder using the revised CESD scale with cutoff > 16		
Depressed	217	48.5
Not depressed	230	51.5
Emotional strain		
Low	300	74.8
High	101	25.2

is listed in Appendix A, and the definition and the detail explanation of the models are provided in Appendix B. Model I shows that the variation of the baseline risk from the context of nursing home is marginally statistically significant: the estimated variance of the random intercept is 0.32, with standard error 0.19; while the variation of the baseline risk from the context of county of residency is minimal: estimated variance is 0 with zero standard error, which indicated no evidence of cross-classification effect between county of residency and nursing home. Model II adds individual variables (e.g., emotional-strain adjusted by age, marital status, and race). This model shows that there was minimal random effect of emotional-strain between nursing homes, and the fixed effect of emotional strain is marginally statistically significant, 0.533 (0.284). Compared with model I, model II shows no reduction of variation in baseline risks from the context of nursing home (0.320 vs 0.322) when adding the individual variables. Therefore, we add level-two variables to explain the variation in baseline risks (model III), namely ownership type, management style, and seniority wage increase. Three important results are shown: First, the fixed effect of emotional strain remains marginally statistically significant when adjusted by level-two variables; Second, the three level-two variables, except managerial pressure, are significantly related to depressive disorder, independently from individual-level variables; Third, the variations of the baseline risk from the context of nursing home was estimated to be minimal (estimated variance = 0), implying that after te inclusion of the nursing home variables as fixed effects, the remaining random variation across nursing homes is negligible. Next, comparison of quasi-likelihood scores between models I, II, and III reveals that fit was improved significantly as tested by the chi- square test. Since there was no remaining variation from the context of nursing home and from the context of county of residency of NAs at level two, model IV, listed in Table 2, is used only to illustrate that adding county level variables did not improve model fit statistically significantly and did not change the main results from model III. Thus, model III was chosen as the final model for depressive disorder (revised CES-D scale).

TABLE 2 Regression Coefficients with Standard Errors for the Multilevel Logistic Regression Analysis of Depressive Disorder

Variables	Model I	Model II	Model III (Final Model)	Model IV
Fixed effects				
Intercept	–0.169(0.15)	–0.038(0.235)	–1.921(0.608)	–2.186(0.657)
Emotional strain		0.533(0.284)†	0.680(0.358)†	0.690(0.370)†
Age group		–0.268(0.267)	–0.161(0.347)	–0.153(0.349)
Marital status		0.141(0.255)	0.188(0.324)	0.269(0.336)
Race group		–0.554(0.403)	–0.571(0.547)	–0.643(0.558)
Nursing home				
Ownership type			1.497(0.468)*	1.605(0.518)*
Seniority wage increase			0.869(0.406)*	0.698(0.465)
Managerial pressure			0.619(0.414)	0.899(0.484)†
County of residency				
Gini Index				–0.200(0.432)
Election vote for Democratic party				0.390(0.444)
Percentage of African American				–0.384(0.357)
Median family income				0.350(0.395)
Random effect variances				
Level 2 variance (county)	0.000(0.000)	0.000(0.000)	0.000(0.000)	0.000(0.000)
Level 2 variance (nursing home)	0.32(0.19)	0.322(0.209)	0.000(0.000)	0.000(0.000)
Level 2 emotional-strain variance (county)		0.000(0.000)	0.000(0.000)	0.000(0.000)
Level 2 emotional-strain variance (nursing home)		0.000(0.000)	0.000(0.000)	0.000(0.000)
Model fit				
Quasi-likelihood deviance	460.56	385.411	240.911	235.166
ΔD		75.15	144.5	5.745
Δ df		4	3	4
Prob. chi square		0.0000	0.0000	0.2190

*$p < 0.05$.
†$p < 0.10$.

Table 3 presents odds ratios and associated confidence intervals of depressive disorder for individual and organizational variables. The results confirmed our hypotheses regarding the association of emotional strain and organizational-level characteristics with depressive disorder. The cross-classified two-level model showed no cross-classification effect observed between location of nursing home and county of residency of NAs. The odds of depressive disorder among NAs with high emotional strain are about twice higher than those of NAs with less strain, adjusted for age, race, and marital status and independent of nursing home characteristics. Organizational-level characteristics are significantly associated with depressive disorder: the odds of having depressive disorder are 4.5 times, 2.4 times, and 1.8 times higher among NAs in for-profit nursing homes, nursing homes not providing seniority-based wage increases, and those with bureaucratic management styles, compared with NAs working in nonprofit nursing homes, nursing homes providing seniority wage increases, and nursing homes with nonbureaucratic management styles, respectively. However, the association between bureaucratic management style and depressive disorder is not statistically significant in our multilevel model.

DISCUSSION

Our findings provide an unambiguous answer to the major question of the study. Thus, results from the cross-classified two-level model suggest that organizational characteristics such as ownership type and wage policies are important correlates of depression among workers providing direct health care even when labor-market-area characteristics are taken into account. Associations with for profit ownership extend findings from nursing home patients[20,32,33] to healthcare workers. Lack of seniority wage increases was also associated with depression among NAs. Cumulative exposure to low income is one of the strongest determinants of depression among U.S. women.[13] In addition, there is a severe cultural stigma associated with women's poverty that, by itself, could also increase the odds of depression.[54] A small increase in statistical power would have yielded a significant statistical association between managerial pressure and depression in the final model. However, previous research suggests that management style can have an effect on mental health.[55–57]

Our reliance on objective indicators of organizational structure (e.g., ownership type) and multilevel analysis[18,43,56,57] supports the presumption that these

indicators are genuine organizational correlates of healthcare workers' mental health.

In addition, organizational-level findings concur with qualitative reports from NAs. In a separate analysis of an open-ended question, overwork, managerial "disrespect," and low pay were identified by participating NAs as the top three most health-determining factors in their nursing homes (authors, 2002). The observed trend linking emotional strain and depression is consistent with hypotheses and findings from human services research[19,43,58] and suggests that emotional labor is an important determinant of healthcare workers' mental health.

Among the limitations of our study we find a cross-sectional design. Nevertheless, reverse-causation explanations are unlikely to hold (e.g., that depressed NAs would know about, have the possibility to choose, and actively seek for-profit nursing homes). The possible bias introduced by studying unionized nursing homes could have produced a less healthy sample, as unionization seems to occur more easily in hazardous workplaces.[59] Nevertheless, a study using government (Center for Medicare and Medicaid Services and Workers Compensation) databases found no differences in injury rates between the nursing homes used in this study and the rest of nursing homes in the state of West Virginia.[59,60]

This study adds a methodologic innovation to multilevel studies in occupational health, namely the application of cross-classified models that take into account simultaneously organizational and area labor-market characteristics. It also incorporates several indicators of work organization that complement workers' subjective assessments of their workplaces. Taken together our findings suggest that future studies of direct-care workers might probe more deeply into the larger economic and policy mechanisms; such as the regulation of for-profit nursing homes, wage-setting policies, and determinants of managerial behavior that may underlie the observed associations with the occupational effects.

It is not possible from our results to directly assess the effects of globalization on NAs' mental health. However, policies leading to our correlates of depression (i.e., emotional strain, for-profit status, managerial pressure, and lower wages) figure prominently as features of globalization. Thus, globalization has been characterized by the deregulation and privation of health services, including the nursing home industry.[61] Deregulation and privatization lead to the intensification of labor and lower wages among less credentialed workforces.[32] Further studies might analyze the direct link between U.S. health policies that deregulate the nursing home industry abroad, as with the expansion of transnational nursing home corporations in Europe and Asia.[29] However, we can conclude that some of the work organization processes that characterize globalization are associated with adverse mental health in U.S. nursing home workers.

TABLE 3 Adjusted Multilevel Odds Ratios of Individual and Organizational Factors Sssociated with Depression Disorder*

	Depressive Disorder (Revised CESD Scale)	
	OR	95% CI
Individual		
Emotional strain	1.97	0.98, 3.98
Organizational		
For-profit status	4.47	1.79, 11.18
No seniority-based wage increases	2.38	1.08, 5.28
Managerial pressure	1.86	0.82, 4.18

*Adjusted for age, race, and marital status.

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Appendix 1

Definitions of Variables Used in the Multilevel Model

	Type	Value
Individual		
Emotional strain	Binary	1 = upper tertile of psychological and emotional demands and lower tertile of decision authority 0 = all other
Age group	Binary	1 = age 45 and over 0 = less than age 45
Marital status	Binary	1 = non married 0 = married
Race group	Binary	1 = non white 0 = white
Nursing home		
Ownership type	Binary	1 = for-profit 0 = nonprofit
Seniority-based wage increase	Binary	1 = No 0 = Yes
Managerial pressure	Binary	1 = Yes 0 = No
County of residence		
Gini Index*	Binary	1 = higher than median 0 = lower than median (median = 39.66)
Election vote for democratic party†	Binary	1 = vote for Democratic 0 = vote for Republic
Percentage of African American‡	Binary	1 = higher than median 0 = lower than median (median = 2.44%)
Median family income‡	Binary	1 = higher than median 0 = lower than median (median = $38,928)

*Original Gini Index for each county from the calculation of Francois Nielsen, Professor of Sociology at University of North Carolina at Chapel Hill, based on U.S. Census 1990. Retrieved at <http://www.unc.edu/~nielsen/data/data.htm>.

†Original presidential election returns in 2000 for each county from *World Almanac & Book of Facts, 2002*. Retrieved at <Academic Search Elite database>.

‡Original data from U.S. Census 2000.

APPENDIX B

Multilevel Modeling

We start with a simplest multilevel model with no individual variables and organizational-level variables. Allowing the risk of outcome to vary across nursing homes and counties of residency, the first-level model is:

$$\text{Logit } P_{i(jk)} = \beta_{0(jk)}$$

where $\beta_{0(jk)}$ represents the risk for ith person at the (jk)th combination of nursing home and county of residency, and the second-level model is:

$$\beta_{0(jk)} = \gamma_{00} + u_{0j} + u_{0k}$$

Then the combined model becomes:

$$\text{Logit } P_{i(jk)} = \gamma_{00} + u_{0j} + u_{0k} \qquad (1)$$

where γ_{00} is the average baseline level of risk at the (jk)th combination of nursing home and county of residency, and u_{0j} represents the deviation of the jth nursing home from the average and u_{0k} represents the deviation of the kth county of residency from the average. The random effects u_{0j} and u_{0k} are assumed to be independent, and each follows a normal distribution with mean zero and an unknown constant variance. The variation of u indicates the amount of variability across nursing homes and counties of residency. MLwiN simultaneously estimates all the fixed-effects γ's and the variance of random-effects u's.

To allow the risk of outcome to vary with individual-level variables, we include individual variables such as emotional strain, ED, in the first-level model:

$$\text{Logit } P_{i(jk)} = \beta_{0(jk)} + \beta_{1(jk)}\, ED_{i(jk)}$$

and to allow both the baseline risk and the odds ratio associated with ED to vary across nursing homes, we have:

$$\beta_{0(jk)} = \gamma_{00} + u_{0j} + u_{0k}$$

$$\beta_{1(jk)} = \gamma_{10} + u_{1j} + u_{1k}$$

Then the combined model becomes:

$$\text{Logit }_{Pi(jk)} = \gamma_{00} + \gamma_{10}\, ED_{i(jk)} + u_{0j} + u_{0k} + u_{1j}\, ED_{i(jk)} + u_{1k}\, ED_{i(jk)} \qquad (2)$$

where γ_{10} is the average log odds ratio associated with ED (may also be referred as the fixed effect of ED) and u_{1j} represents the deviation of the jth nursing home from the average and u_{1k} represents the deviation of the kth county of residency from the average. The random effect (u_{0j}, u_{1j}) and (u_{0k}, u_{1k}) are assumed to follow a multivariate normal distribution with zero mean and an unknown variance–covariance matrix.

The group-level variable, such as ownership type of nursing home, OT, and Gini Index of county of residency, GI, may be used to explain the heterogeneity in baseline risks for outcomes across the nursing homes and counties of residency such that:

$$\beta_{0(jk)} = \gamma_{00} + \gamma_{01}\, OT_j + \gamma_{02}\, GI_k + u_{0j} + u_{0k}$$

In this case, the combined model becomes:

$$\text{Logit } P_{i(jk)} = \gamma_{00} + \gamma_{01}\, OT_j + \gamma_{02}\, GI_k + \gamma_{10}\, ED_{i(jk)} + u_{0j} + u_{0k} + u_{1j}\, ED_{i(jk)} + u_1 k\, ED_{i(jk)} \qquad (3)$$

where γ_{01} represents the influence of OT on the log odds of the outcome and γ_{02} represents the influence of GI on the log odds of the outcome. Here, the model (3) corresponds to model IV presented in Table 2. If there is no county-level variables such as GI included, the model (3) without GI corresponds to model III presented in Table 2.

The successive construction of the mult-level models is based on the improvement of model fit and the reduction of random-effects variations.