

Incarceration as Exposure: The Prison, Infectious Disease, and Other Stress-Related Illnesses*

MICHAEL MASSOGLIA

Pennsylvania State University

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This article examines the relationship between incarceration and health functioning. Using data from the National Longitudinal Survey of Youth, the relationship between incarceration and more than 20 different measures of health are tested. Using multiple analytic procedures, a distinctive pattern of association emerges. Individuals with a history of incarceration appear consistently more likely to be afflicted with infectious disease and other illnesses associated with stress. In contrast, no consistent relationships were observed between incarceration status and ailments unrelated to stress or infectious disease. The results suggest that exposure to infectious disease and stress are important to understanding the lasting impact of incarceration on health.

Over the last 30 years, the size and scope of the United States penal system has increased dramatically; the number of incarcerated individuals has increased almost eightfold since the 1960s. The penal system has expanded so rapidly that incarceration is now considered a stage in the life course for some subgroups of the population (Pettit and Western 2004). For instance, by their early thirties, black men have approximately a 20 percent cumulative risk of incarceration. The risk for comparably aged whites is approximately 3 percent. Black men without high school diplomas have nearly a 60 percent cumulative risk of incarceration by their early thirties, compared to an 11 percent chance for similarly educated whites (Pettit and Western 2004).

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These staggering numbers have spurred a tremendous proliferation of research on the later-life consequences of incarceration and experience with the justice system (Pager 2003; Pettit and Western 2004; Uggen and Manza 2002). This research generally examines the deficits—social, economic, or cultural—of former inmates upon release and the problems they face re-integrating into society. Recent work has extended this to a consideration of health outcomes (Freudenberg et al. 2005; Massoglia forthcoming; Schnittker and John 2007). This emerging line of research is varied in its health focus, examining issues such as self-reported general health, chronic health conditions, or community health problems. In explaining these findings, researchers generally cite factors such as exposure to disease while in prison and the stress and stigma of incarceration (for instance Schnittker and John 2007).

Typically because of data limitations, however, these processes—exposure to infectious disease and stress—are often inferred. Using multiple health outcomes, this article attempts to assess more explicitly the relationship between incarceration and health. In all, some 24 different health measures are considered, ranging from serious problems such as heart failure and tuberculosis to relatively minor indicators such as chronic headaches. The results present

an interesting picture of the relationship between incarceration and health. Inmates and ex-inmates appear consistently more likely to report health problems that are associated with stress or communicable infectious disease. In contrast, there appears to be little or no relationship between incarceration status and illnesses unrelated to stress or infectious disease.

THEORY AND EVIDENCE

Criminal Punishment as a Health Issue

There is ample evidence to suggest a correlation between incarceration and health status at both the individual and the community levels. For instance, one study reported that 15 percent of all individuals infected with HIV and approximately 40 percent of all individuals infected with hepatitis C passed through correctional institutions (Travis, Solomon, and Waul 2001). Thus, many individuals with serious illnesses pass through correctional agencies every year (Beck and Maruschak 2001; National Commission on Correctional Health Care 2002; Travis et al. 2001). While not suggestive of a causal association, these statistics suggest the need for additional analysis of the incarceration-health relationship.

Additionally, these high rates of disease and illness suggest that public health officials may need to examine the role of the penal system in the administration of health care. In fact, other than hospitals, correctional agencies appear to present one of the best opportunities with which to intervene in the lives of individuals who are managing illness. From a health perspective, prisons disproportionately house those with disadvantaged health profiles across a number of social and economic indicators.

Exposure to Stress and Disease While Incarcerated, and Secondary Stressors After Release

Theorizing the process by which incarceration affects later health requires a consideration of both the conditions of confinement as well as the life that inmates face after release. While incarcerated, individuals are exposed to high levels of infectious disease (see for instance Travis et al. 2001). This exposure provides a relatively clear link between incarceration and later health outcomes. Drawing on the stress literature to explain the relationship between incarceration and health requires an extension of existing stress theory. While some institu-

tional variation is no doubt evident, accounts of prison life suggest prisons are highly stressful environments (Hassine 2004; Abbott 1981). Additionally, a wealth of emerging work examines the stressors that inmates face across different social settings—family, employment, civic—when trying to re-enter society after release (Western 2002; Manza and Uggen 2005). In part, inmates face these difficulties because they are such a highly stigmatized subgroup of the population (Uggen et al. 2004).

In explaining the immediate and lasting relationship between incarceration and stress processes, Pearlin's (1989) work on primary and secondary stressors is particularly applicable. Primary stressors can be seen as events—the death of a loved one, involuntary job loss—that are both stressful themselves and produce a series of additional stressors, termed secondary stressors. For Pearlin (1989), the key notion is that “important problems, whether in the form of events or durable strains, do not exist in isolation from other social problems” (p. 248). Applying this process to the prison system, the experience of incarceration likely acts as a primary stressor, while characteristics of life after release—stigma, decreased earnings and employment prospects, and family problems—are a series of secondary stressors. Taken together, these primary and secondary stressors negatively impact health. Before more explicitly elaborating on the primary and secondary stressors associated with incarceration, the potential association between incarceration and exposure to infectious disease is considered.

Prison as Exposure to Infectious Disease

Epidemiologists have long considered how exposure to risk factors for disease plays an important role in the etiology of health and illness. Estimates from the National Correctional Commission Report (2002) are consistent with other work (Travis et al. 2001) finding high rates of infectious disease in correctional institutions. These high rates of infectious disease and the living conditions of prison—shared hygiene facilities, residential crowding, high levels of intimate contact—may provide fertile ground for illness transmission. There is evidence supportive of correctional facilities spreading infectious disease; several outbreaks of tuberculosis in the United States have been traced to correctional facilities (Farmer 2002). In fact, Farmer (2002) argues that rates of tu-

berculosis in the New York facility Rikers Island were higher than rates of many countries in the developing world. These high rates of infectious disease offer a link between incarceration and health outcomes. If the prison acts to disproportionately expose individuals to infectious disease, then the analysis should reveal increased infectious disease among those with a history of incarceration.

Life Inside: Incarceration as a Primary Stressor

In addition to differentially exposing individuals to infectious disease, the incarceration experience may differentially expose individuals to stressors over the life course. In explaining the relationship between stressors and health, one major thrust of research focuses on major life events. Consistent with notions of primary stressors, the key theoretical idea is that these events are moments that require “major behavioral adjustments in a relatively short period of time” (Thoits 1995:54). Major life events have been linked to a number of detrimental health outcomes, including psychiatric disorder, mortality, and physical morbidity (Kessler, Price, and Wortman 1985; Cohen and Williamson 1991; Thoits 1986, 1995). Incarceration may be an event that causes a major adjustment in a short time period and thus affects health in a manner consistent with the life events framework. Indeed, there is a somewhat dated literature on inmate adjustment that examines the problems and stress inmates face in making the transition to life inside prison (Sykes 1958; Zingraff 1980). Additionally, ethnographic accounts of prison life almost universally identify the changes that accompany prison life as difficult and stressful (Abbott 1981; Hassine 2004).

From a stressful (or major life events) perspective, the key mechanism linking incarceration and health is differential exposure to stressors as a result of the prison experience. Recent work has shown that severe or chronic stress can permanently weaken the body’s ability to respond to additional stressors and manage health (McKwen 1998; Fremont and Bird 2000) through a process referred to as the allostatic load (Evans, Barer, and Marmor 1994; Halfon and Hochstein 2002). Formally, the allostatic load can be defined as “the cumulative toll on the body from elevated use of physiologic systems” (Smith 1999:162). Elevated use of the physiological system strains the immune

and cardiovascular systems, and, over time, the body is unable to return to its prior state of functioning and is more vulnerable to illness (Lazarus and Folkman 1984; Pearlin 1989). In a similar manner, the stressors associated with incarceration may permanently weaken an individual’s ability to cope and adjust to stressors, leaving individuals at increased risk for some physical health problems. Consistent with the major life events framework, an analysis of the impact of incarceration on health may be most evident among ailments—for instance hypertension—thought to be, along with other risk factors, associated with stress.

Moreover, the stressors presented by incarceration likely have implications for infectious disease. Cohen and colleagues (e.g., Cohen and Williamson 1991), for instance, have shown that stressful experiences can make individuals more vulnerable to infectious agents. Thus, in addition to being exposed to higher levels of infectious disease, the stress of incarceration likely makes individuals more vulnerable to such diseases.

Life After Release and Secondary Stressors: Stigma and Social Hierarchy Positioning

Literature on stigma and social hierarchy suggests that factors both inside and outside of the prison setting work to impair health. Incarceration and contact with the justice system lower an individual’s standings across a number of social (Uggen, Manza, and Behrens 2004) and economic indicators (Western 2002). Ex-inmates have reduced economic and labor market opportunities and are highly stigmatized, which results in lower social standing. These reduced opportunities, stigma, and lower social standing are consistent with Pearlin’s (1989) notion of secondary stressors and have implications for health.

The Whitehall studies serve as the foundation for a research agenda examining how social standing or position on a social hierarchy impact health. These studies are among the most important works on the life course determinants of health (Marmot, Shipley, and Gibson 1984; Marmot 2004; Bosma et al. 1998). Marmot measures social standing through the differing job classes individuals held, ranging from administrative and executive positions to clerical positions. Marmot concludes that people at the lower end of the social gradient were at greater risk for health problems (Marmot et al. 1984; Marmot 2005).

In large part, Marmot argues that health is related to an individual's ability (or perceived ability) to control his or her life and participate fully in society (e.g., Marmot et al. 1984, 2004). Those at the lower end of the social gradient are less able to participate in society and exercise control over their lives. Conversely, those at the top of the social gradient are more apt to have control over their lives and to participate fully in society.

Given Marmot's theoretical perspective, the specific intent and goals of incarceration are inconsistent with positive health outcomes, for multiple reasons. One goal of the penal system is to remove individuals from participating fully in society, and correctional procedures are devoted and implemented to prevent inmates from having control over their lives. Upon release from prison, ex-inmates face a series of social and correctional policies that restrict societal participation. Many ex-felons are barred from full participation in society, lacking rights such as voting and participation in other public programs (Maruna and Immarigeon 2004; Mauer and Chesney-Lind 2002; Petersilia 2003; Manza and Uggen 2005).

Aside from these legal restrictions, the stigma associated with status of "ex-con" acts as an additional barrier leaving individuals unable to participate in society and exercise control over their lives. In perhaps the most direct statement on the matter, Irwin (1985) terms inmates the "underclass of society." More recent work also finds that inmates are a highly stigmatized subgroup of the population (Uggen et al. 2004). Ex-inmates are less likely to have jobs, and those who have jobs are likely to have wages lower than their non-felon counterparts (Pager 2003; Western 2002). In sum, the recent evidence indicates that incarceration has a detrimental impact on social status (Manza and Uggen 2005; Maruna and Immarigeon 2004; Mauer and Chesney-Lind 2002; Pager 2003; Petersilia 2003; Western 2002). Extending this literature, therefore, suggests that, even after release, the incarceration experience likely invokes a series of secondary stressors that have negative implications for health functioning.

Prior empirical and theoretical work suggests two related hypotheses regarding the relationship between incarceration and health functioning. First, incarceration affects the health of inmates by disproportionately exposing them to infectious disease. Second, incarceration and the related status as an ex-con and

felon upon release act as primary and secondary stressors in the lives of incarcerated individuals, increasing their likelihood of other stress-related illness. The present study examines these hypotheses. As noted earlier, it is important to recognize that these two hypotheses are not completely independent of one another, as stress can increase an individual's susceptibility to many types of illnesses, including infectious disease.

DATA, LOGIC OF ANALYSIS, AND METHODS

Data

Consistent with other work examining the impact of incarceration (Lopoo and Western 2005; Western 2002), this analysis uses data from the National Longitudinal Survey of Youth 1979 (NLSY). Data collection began in 1979 and is ongoing. The original NLSY sample included more than 12,000 individuals and utilized a multistage stratified probability sample of U.S. dwellings. Starting in 1998, the NLSY collection protocol included a comprehensive health questionnaire. The "health 40" module was administered only once to respondents during the survey period immediately after she or he turned age 40, in survey years 1998, 2000, or 2002, depending on the respondent's age at the beginning of the sample.¹ As of 2002, 5,556 individuals (out of more than 8,000 remaining respondents) have turned 40 and answered the module. Respondents answered the health 40 module only once. Although sample attrition is not thought to be problematic in the NLSY (Macurduy, Mroz, and Gritz 1998; Western 2002), weights are used to make the sample nationally representative.²

To assess the relationship between incarceration and health, more than 20 different indicators of health are estimated, all independently. These different measures of health serve as the dependent variables in this analysis. These indicators fall into two different categories. First, respondents are asked whether they suffer from any of a number of health ailments. Second, respondents are asked whether they have been diagnosed with any of a number of medical illnesses by a doctor or other health professional. The measures, listed in Tables 2 and 3, range from very mundane conditions such as chronic headaches to the very severe, including heart failure, cancer, and infectious disease such as tuberculosis and hepatitis. Importantly, these diseases do not all share

identical risk factors. Some, such as hypertension, are more strongly associated with stress (Zimmerman and Frohlich 1990), while others, such as hepatitis and tuberculosis, are infectious diseases. Others, such as anemia (Beers 2004) or cancer (Garssen and Goodkin 1999), appear weakly related or unrelated to such processes. In all cases the NLSY codes respondents as either having or having been diagnosed with the ailment, with individuals responding affirmatively being assigned a value of 1.

Demographic Indicators, Life Course Processes, and Substance Use

In estimating the relationship between incarceration and health, the analysis accounts for a number of factors important to health functioning, including demographic indicators such as gender and race. Descriptive statistics for all variables are reported in Table 1.

In addition to background variables, a series of lifestyle processes are accounted for in the analysis. These include respondents' reported weight, exercise habits, and levels of cigarette use and binge drinking. The analysis also includes contemporaneous life course and social indicators, including age 40 educational level and marital and employment status.

Focal Independent Variable and Lagged Measure of Health

All statistical models include an indicator of prior health problems, measured as whether respondents report a health problem that prevents them from performing social or work func-

tions. This measure is taken prior to risk of incarceration and helps attenuate bias introduced from unmeasured sample heterogeneity. More specifically, prior health problems are measured in survey year 1979, and the analysis considers only spells of incarceration from 1980 forward. This helps ensure that the measurement of self-reported health problems precede the measurement of incarceration. Approximately 6 percent of the sample report prior health problems.

The focal independent variable is incarceration, measured on the NLSY as a place of residence indicator. More specifically, this measure is a yearly indicator of whether the respondent was incarcerated at the time of the survey (Harper and McLanahan 2004). As noted by others (Harper and McLanahan 2004; Western 2002), the collection protocol is such that "jail spells shorter than 12 months are underobserved. . . . Prison sentences (which typically exceed 12 months) are observed with certainty" (Western 2002:530). Others reach similar conclusions, noting that the NLSY is "more likely to capture spells lasting longer than a year" (Harper and McLanahan 2004:375). As such, the indicator depicts substantial and invasive contact with the correctional system characteristic of more serious and chronic offenders, as opposed to more passing contact with the correctional system (Harper and McLanahan 2004).

Approximately 5 percent of the sample have been incarcerated, disproportionately minorities, with the mean length of incarceration being more than three years. To protect the logic of analysis, incarceration is measured from

TABLE 1. Descriptive Statistics

Variable	Description	Coding	Mean	Std. Dev.
Gender	Self-reported gender	0 = female, 1 = male	48%	
Race	Self-reported race	0 = other, 1 = white	71%	
Prior health problems	Does the respondent have health problems that limit the type or amount of work they can do? (Measured in 1979, prior to risk of incarceration period.)	0 = no, 1 = yes	6%	
Workout	Number of times weekly the respondent participates in vigorous physical activities	1 = never, to 5 = more than three times a week	2.76	.47
Weight	Respondent's weight in pounds	0-370	174.9	41.41
Cigarette use	Does the respondent report daily cigarette use?	0 = no, 1 = yes	27%	
Binge drinking	Does the respondent drink more than five drinks at least 2-3 times a month?	0 = no, 1 = yes	19%	
Marital status	Is the respondent married?	0 = no, 1 = yes	56%	
Labor force participation	Is the respondent in the labor force?	0 = no, 1 = yes	73%	
Incarceration	Respondent incarcerated between 1980-1998?	0 = no, 1 = yes	4.9%	

Note: N = 5,428.

1980 until 1998. This analysis considers incarceration as an exposure variable; individuals either are exposed to the incarceration setting (coded 1 if incarcerated at any point during the survey years 1980 through 1998) or they are not (coded 0 if they were never incarcerated). This was done for both theoretical and empirical reasons. Theoretically, research on life events emphasizes the occurrence of an event and the stress or rapid life change that is resultant from that event.

Additionally, other empirical research also supports this position. In an analysis of chronic health limitations, Schnittker and John (2007), for instance, conclude that “the effects of incarceration are such that contact with the prison system is generally more important than the amount” (p. 125). Consistent with this finding, supplementary analysis revealed that exposure to incarceration, rather than length of incarceration, appears to be more important to the relationship between incarceration and health problems. In the vast majority of the models tested here, in the presence of a measure capturing exposure to incarceration, the length of incarceration is a nonsignificant predictor of the range of health outcomes considered in this article. This is shown in model 2 of the table presented in the Appendix.

Logic of Analysis

Prior theoretical and empirical evidence suggests that stress and exposure to infectious disease are two key processes to understanding the relationship between incarceration and health. To assess this relationship, the analysis considers a spectrum of health outcomes from rather minor ailments such as chronic headaches to severe illness such as hepatitis, tuberculosis, and heart failure.³

This range of outcomes is informative for many reasons. It allows for a more specific test of the relationship between incarceration and health than do more general measures such as self-reported general health (Massoglia forthcoming) or chronic health problems (Schnittker and John 2007). Additionally, the pattern of association between health and incarceration allows for specific inferences about the mechanisms linking incarceration and health. Three possible patterns seem most likely. One pattern could show no significant relationship between incarceration and any illnesses. That would suggest that the claims of the detrimental impact of incarceration on health appear overstated.

A second pattern could also emerge, where inmates are disproportionately likely to have illnesses associated with either stress or infectious disease, but not other ailments. This would support the specific mechanisms discussed in the literature review and considered by other researchers (Johnson and Raphael n.d.; Massoglia forthcoming).

If, however, a third pattern emerges, a pattern wherein inmates are disproportionately likely to have all types of illness, then the mechanisms linking health and incarceration may be underappreciated and mis-specified by extant work. Stress and infectious disease, while perhaps still important, are not the key processes linking incarceration status and health. This may be a problem of spuriousness. Those who are incarcerated may be more likely to engage in a range of behaviors—gun violence, drug use—that also lead to detrimental health outcomes.

To address concerns about selection, two different analytical procedures are employed. First, for each different outcome, estimates of the relationship between incarceration status and health are generated using logistic regression with covariate adjustment. Second, estimates of the relationship between incarceration and health are derived using propensity score analysis (formally presented below). Broadly stated, propensity estimators attempt to replicate an experiment with nonexperimental data. Propensity score models are becoming increasingly common in both health and justice studies (e.g., McCaffrey, Ridgeway, and Morral 2004; Ridgeway 2006). Propensity score models are essentially a two-step procedure. First, the models match individuals on their likelihood or propensity to experience a treatment, in this case incarceration, such that treated individuals (those incarcerated) are paired with controls (nonincarcerated individuals) who have identical or similar propensity scores.⁴ This serves to make the sample homogenous, except for the treatment (incarceration) experience. Next, estimates are derived by comparing differences between treated and control individuals (Morgan and Harding 2006). Given the sample homogeneity, the incarceration experience is taken to have occurred at random, and differences between the treated and control samples represent the estimated causal effect of incarceration on health as all other factors—including population differences in health status and illness—have been accounted for in the

propensity equation or randomized out through the matching process.

Treatment Effects and Propensity Score Models

As typically used, regression models capture mean differences across different groups of people, be they married or single, employed or unemployed, or, in this case, incarcerated or not incarcerated. Under conditions where experiencing such events occurs at random and no significant unmeasured heterogeneity exists in the sample prior to treatment, regression models likely represent the actual treatment effect. Given the high likelihood that these conditions are violated when considering incarceration, this article estimates the effect of incarceration on later health using propensity matching estimators.

The logic of treatment effects is rooted in counterfactual reasoning. In the present analysis, health outcomes attributed to incarceration must be measured against health outcomes that would have been observed had incarceration not occurred. The problem is essentially one of missing data; it is not possible for individuals to be in both the treated (ever incarcerated) and untreated (never incarcerated) state (Morgan 2001; Winship and Morgan 1999).

In order to overcome the problem of missing data, propensity score methods focus on modeling the likelihood, or propensity, that an individual will experience a treatment. They then compare differences across individuals with like propensity scores but different treatment scores, meaning that based on observed covariates, two individuals have the same, or very similar, likelihood of experiencing incarceration, but only one of them did. To estimate propensity of incarceration, the models use background characteristics and behavioral indicators that are predictive of incarceration status (Rosenbaum and Rubin 1983; Winship and Morgan 1999; Morgan 2001; Harding 2003). Formally, the propensity score, which in this case represents the conditional probability of incarceration, is

$$p(\text{incarceration}) = \Pr(T_i = 1|X_i) \quad (1)$$

where $T_i = 1$ if individual i is incarcerated and X_i is a vector of covariates, including any interaction terms, that predict incarceration. Because the propensity score is estimated with

a logit model, the propensity score can be expressed as

$$\Pr(T_i = 1|X_i) = \exp(X\beta_i)/(1+\exp(X\beta_i)) \quad (2)$$

A variety of matching algorithms can be used to pair incarcerated individuals (treated) with similar nonincarcerated individuals (controls) on the basis of their propensity score. Under conditions where the treated and untreated samples have identical scores across relevant variables, the covariates and thus the samples are considered to be balanced (Harding 2003; Morgan 2001; Rubin 1985). Substantively, a balanced sample is one where there are no differences between the treated and control group on the covariates used to predict treatment. Sample balance is essential for researchers to view the treatment as random and is thus a key assumption of propensity models, often referred to as the ignorable treatment assumption. This analysis uses STATA and the estimation methods developed by Becker and Ichino (2002) to test for covariate balance.⁵

This article uses nearest neighbor matching procedures to construct the matched sample used for analysis.⁶ Neighbor matching is a straightforward and parsimonious way to create a matched sample for subsequent analysis. A propensity score between 0 and 1 is estimated for every individual in the sample, independent of incarceration history. As implied by the name, nearest neighbor matching identifies the propensity score of all incarcerated individuals and then selects a nonincarcerated individual whose propensity score is closest to each incarcerated individual. Once the matched sample is created, analysis is then done—generally focusing on average differences between the treated and the controls—on this newly created sample to determine the treatment effect (Morgan and Harding 2006). This analysis uses regression on the matched sample to assess average differences in the probability of having a range of different health ailments (see Morgan and Harding 2006:37–39).

To generate the propensity scores presented in equations 1 and 2, the key component of the equation is the vector of covariates X_i used to predict treatment status. In this analysis the observed covariates are a series of relevant factors that predict incarceration status, including race; gender; prior health problems; drug use; whether the respondent grew up in a two-

parent household, graduated high school, had a job, or lived in an urban or rural setting; levels of self-reported violent acts, arrest, and self-esteem; and marital status. The matching equation also includes interactions between race and education, race and gender, race and drug use, race and violent crime, race and arrest, and race and intact family. Additionally, interactions were constructed for gender and arrest, gender and drug use, gender and violent crime, and gender and intact family. Finally, a number of three-way interactions were created between race, violent crime, and drug use, as well as race, violent crime, and arrest, and, finally, race, drug crime, and arrest.⁷

Two additional aspects of the matching estimators are noteworthy. First, all analyses are restricted to regions of common support. Broadly defined, the region of common support is simply a range of propensity scores shared by both treated and matched individuals. If an individual is outside of the region of common support, he or she is omitted from analysis, even if he or she is the nearest match to a treated individual. Substantively, this excludes outliers—identified on the basis of their propensity score—from the analysis and helps further ensure the homogeneity of the treated and control samples. Second, the matching equation includes an indicator of prior health problems. This ensures that the results are not simply a function of preexisting differences in measured health problems. Additionally, it models whether prisons disproportionately select those with a history of health problems.⁸

Finally, the propensity score equation includes many indicators of crime and involvement with the justice system. That is, this matching equation considers criminal justice processes up to, but not including, incarceration. This helps ensure that the estimated treatment effect represents an actual incarceration effect rather than that of criminal behavior or more fleeting contact with the justice system, such as arrest.

RESULTS

Propensity Score Models: Model Diagnostics

Before presenting the parameter estimates, the appropriateness of the matching equation is considered. One way this can be done is in terms of the quality of the match, meaning the similarity between treatment and controls, as well as quantity of suitable matches, meaning the number of incarcerated individuals who

have like matches. Including factors such as arrest, drug use, and self-reported crime helps create a matching equation well-suited to place individuals in the treatment state of incarceration. Moreover, the specific criminal behavior indicators included, violence and drug use, are particularly predictive of incarceration (Blumstein and Beck 2000). Even after restricting the analysis to regions of common support, more than 95 percent of incarcerated individuals are matched with appropriate nonincarcerated controls. This gives a matched sample of 536 individuals, equally divided between incarcerated and nonincarcerated individuals.

The strength of the matching equation is further evidenced in the diagnostic results of the similarity of the treatment and control groups. The estimation procedure and algorithm used for this analysis (Becker and Ichino 2002) specifically test for covariate balance, and the samples satisfy the balancing property. Despite this safeguard, diagnostic analyses were conducted to specifically test for differences between the treated and nontreated samples on any of the variables included in the matching equation. As would be expected, given that the balancing property is satisfied, tests for mean differences across samples did not reveal any significant differences between the treatment group and control group (available upon request). This indicates that one of the key—even necessary—components of propensity score matching is satisfied. Given the covariates in the matching equation, the treatment and control groups are not significantly different except for incarceration status.⁹

Logistic and Matching Estimates

For ease of presentation, Tables 2 and 3 report only the parameter estimates of substantive interest (full model information for each of the models estimated is available upon request). As previously mentioned, the breadth of the relationship between health and incarceration is assessed from two different sources. In Table 2, respondents report whether they have been diagnosed by a medical professional as having any number of specific health problems. Next, in Table 3 respondents report the extent to which they have a number of specific health problems.

The results presented in Tables 2 and 3 indicate that inmates are not universally more likely to have all illnesses. As reported in Table 2,

TABLE 2. Logistic Regression and Propensity Matching Estimates of the Relationship between Incarceration and a Medical Diagnosis of Health Problems

Medical diagnosis of:	Logistic Regression Estimates		Matched Sample Estimates	
	Est.	SE	Est.	SE
Direct/strong link to stress				
Nervous or psychological problems	1.416	(.25)***	1.494	(.40)***
(95% C.I. lower limit)	1.005		.836	
Hypertension	1.506	(.15)***	1.517	(.21)***
(95% C.I. lower limit)	1.259		1.171	
Heart problems	.668	(.33)*	.735	(.48)
(95% C.I. lower limit)	.125		-.20	
Chronic lung disease	2.808	(.21)***	3.032	(.38)***
(95% C.I. lower limit)	2.462		2.407	
Indirect/weaker/not linked to stress				
Arthritis	.304	(.22)	NS	
Cancer	.298	(.81)	NS	
Diabetes	.363	(.35)	NS	

* $p < .05$; ** $p < .01$; *** $p < .001$ (one-tailed tests)

Notes: N = 5,428 (logistic regression) and 526 (matched models). NS = Non-significant estimates. All logistic regression models estimated separately controlling for race, gender, prior health problems, exercise frequency, self-reported weight, marriage status, employment status, alcohol consumption, cigarette use, and cohort dummy terms. As noted earlier, some studies have found a link between stress or infectious agents and some types of lung disease, but this does not apply to all types of lung disease.

inmates are no more likely than are similarly positioned noninmates to be diagnosed with cancer, diabetes, or arthritis. There are, however, some illnesses that disproportionately impact inmates. Despite the complexity in defining and precisely isolating the role of stress

TABLE 3. Logistic Regression and Propensity Matching Estimates of the Relationship between Incarceration and Self-Reported Health Problems

	Logistic Regression Estimates		Matched Sample Estimates	
	Est.	SE	Est.	SE
Infectious disease				
Urinary tract infections	2.426	(.43)***	1.321	(.65)*
(95% C.I. lower limit)	1.718		.251	
Hepatitis or TB	1.833	(.35)***	1.823	(.63)***
(95% C.I. lower limit)	1.257		.786	
Direct/strong link to stress				
Chest pain, heart problems	.714	(.27)**	.772	(.38)*
(95% C.I. lower limit)	.269		.15	
Depression, excessive worrying	.818	(.21)***	.584	(.27)*
(95% C.I. lower limit)	.47		.147	
General health problems	.556	(.22)**	.645	(.30)*
(95% C.I. lower limit)	.194		.161	
Problems sleeping	.221	(.19)	.525	(.25)*
(95% C.I. lower limit)			.113	
Chronic headaches or dizziness	.343	(.23)	.898	(.34)**
(95% C.I. lower limit)			.338	
Indirect/weaker/not linked to stress				
Epilepsy	.463	(.51)	NS	
Skin problems	-.411	(.49)	NS	
Allergies or frequent colds	-.258	(.21)	NS	
Tooth or gum problems	.319	(.26)	NS	
Thyroid trouble	-.163	(.66)	NS	
Back problems	.206	(.22)	NS	
Anemia	.255	(.50)	NS	
Low blood pressure	-.121	(.44)	NS	
Gallbladder problems	-.047	(.25)	NS	

* $p < .05$; ** $p < .01$; *** $p < .001$ (one-tailed tests)

Notes: N = 5,428 (logistic regression) and 526 (matched models). NS = Non-significant estimates. All logistic regression models estimated separately controlling for race, gender, prior health problems, exercise frequency, self-reported weight, poverty status, employment status, alcohol consumption, cigarette use, and cohort dummy terms.

in the etiology of illness (Greenberg 1993; Holt 1993), these ailments are, to varying levels, generally thought to be more strongly associated with stress (Greenberg 1993). More specifically, odds ratios (the exponentiation of the logistic regression estimates) indicate that incarcerated individuals are at least four times as likely to report a diagnosis of hypertension (Yan et al. 2003), emotional and psychological problems (Pearlin 1999), or chronic lung illness (Horne and Picard 1979; Holt 1993; Cohen, Doyle, and Skoner 1999). Finally, ex-inmates are almost twice as likely to be diagnosed with heart problems (Greenberg 1993). The results from the matching estimators generally support the results of the logistic regression. Even after randomizing out differences between incarcerated and nonincarcerated individuals, ex-inmates are disproportionately more likely to get some illnesses, but not all illnesses.¹⁰ While clearly not definitive, based on the analysis of diagnosis of medical health problems, there is partial support for the explanation that the stress of the incarceration experience has negative effects on health functioning at age 40.

Table 3 presents self-reported health problems. Again, there is evidence that inmates experience illnesses at a disproportionately higher rate, and that stress appears to be a common thread across these illnesses. For instance, as seen in earlier analyses, inmates are significantly more likely to report psychological problems. According to the propensity models, they are also more likely to report problems sleeping, chronic headaches, dizziness, and heart problems.¹¹ Table 3, however, also suggests that incarceration exposes inmates to infectious disease. Regardless of the analytic procedure, ex-inmates are almost four times more likely than noninmates to report urinary tract infections, hepatitis, and tuberculosis. This suggests that infectious diseases, which may be spread through the close living conditions or intimate contact common in the prison setting, may also play a significant role in the incarceration-health relationship.

In sum, the results present evidence that the prison experience lowers later health functioning. Even after testing the relationship with multiple methods and controlling for health problems prior to incarceration, inmates are more likely than noninmates to have health problems across different indicators of health. It is the pattern of illness, however, that is most

illuminating in understanding the relationship between incarceration and health. Inmates are not more likely to have all illnesses. Rather, inmates are more likely to have only some illnesses, including hepatitis, heart problems, hypertension, and depression. Consistent with propositions presented in earlier sections of this article, the pattern of illnesses in Tables 2 and 3 provides suggestive evidence that exposure to infectious disease and stress—both while in prison, perhaps, and as a function of the stigma associated with “ex-con” status upon release—may account for part of the lasting relationship between incarceration and health.

DISCUSSION

The empirical results indicate that stress and exposure to infectious disease appear important in understanding the relationship between incarceration and health. Both have roots in work on residential location, or the neighborhood tradition. While variants exist, the neighborhood tradition examines how residing in neighborhoods either exposes individuals to factors that affect health, or limits their exposure (Aneshensel and Sucoff 1996; Aneshensel and Phelan 1999; Browning and Cagney 2002, 2003; Ross, Mirowsky, and Pribesh 2001; Ross and Mirowsky 2001; Sampson 2003). Neighborhoods characterized by high levels of fear, incivility, and disorder negatively affect health by exposing individuals to high levels of stress. Linking this tradition to incarceration, the task is to conceptualize the prison as a neighborhood and consider whether the residential conditions of prisons are characteristic of the most disadvantaged neighborhoods: high crime, incivility, and stress. This is borne out empirically, as inmates are more likely to report and be diagnosed by a medical professional as having health problems that appear to be associated with stress.

In light of research suggesting that stress can irreparably alter the body’s ability to manage life stressors and maintain optimal physical and mental health (Evans et al. 1994; McKwen 1998; Fremont and Bird 2000; Smith 1999), the stress of prison life may fundamentally damage the body and worsen some health outcomes. This finding is consistent with other research indicating that the prison experience can lead to a number of contemporaneous health problems (Liebling 1999; Liebling and Maruna 2005).

Finally, the high rates of infectious disease evident in prison offer evidence linking incarceration to health outcomes. Incarceration exposes individuals to a number of infectious diseases, including HIV, hepatitis B, hepatitis C, and tuberculosis (Farmer 2002; Talvi 2003; National Correctional Commission Report 2002). Additionally, the conditions of confinement are ripe for the spread of infectious disease. Classic disease risk factors ranging from communal hygiene facilities and crowded living conditions to drug use and unsafe sexual practices are all common to the correctional setting (Nelson, Williams, and Graham 2005).

When considered against the dramatic rise of incarceration rates over the last 20 years (Western 2002), the results indicate the reach of the penal system extends into areas not discussed in prior research and provides some evidence of the mechanisms—stress and exposure to infectious disease—that may explain part of this relationship. Even when controlling for prior health and using multiple matching estimators, the impact of incarceration on a range of health outcomes is striking. Given the detrimental impact of incarceration on health and the high number of inmates released yearly, the penal system may have a transformative effect on aggregate health and the health care system. As the masses of ex-felons increase both in number and age, the health care needs of ex-inmates may represent an emerging crisis facing the health care system. There is perhaps no social institution that is both so pervasive and so damaging to the lives of individuals who come into contact with it as the penal system.

CONCLUSION

The empirical results, through both the significant and nonsignificant relationships, indicate that incarceration exerts negative effects on health. Clearly, part of the incarceration-health relationship works through life course factors associated with both prison and health; however, even after accounting for these processes (logistic regression) or randomizing them out (matching models), incarceration remains a strong predictor of health.

While prior work and the empirical results indicate that there are two mechanisms—stress and exposure to infectious disease—linking incarceration and health, more research is clearly needed. For example, researchers would be well served to gather data with direct measures

of stress and encompassing a greater range of infectious diseases, including HIV. Moreover, because the analysis seems to suggest that the relationship between incarceration and infectious disease is somewhat stronger than the relationship between incarceration and stress-related illnesses, future research needs to confirm and substantiate these results with other measures of health. Along similar lines, while the NLSY is uniquely suited among existing representative data sets to examine the impact of incarceration on health, it was not designed for this purpose. Further research in the area would be greatly advanced by collecting health data on incarcerated individuals and those who have been recently released. In particular, rather than the simple measures collected in the NLSY, more detailed measures—e.g., severity, timing of onset, or length of health problems—would be particularly informative in helping specify whether the prison experience itself or the stressors after release are most responsible for the relationships found in this analysis. It is also noteworthy that the sample is still reasonably young (age 40). The long-term health consequences of prison may be hard to discern, and indeed some problems may not have yet emerged because of the age of the sample.

Additionally, while the propensity models utilized in the article provide a rigorous test of the incarceration-health relationship, they are sensitive to bias from unmeasured processes. If, for instance, unmeasured processes unrelated to the observed variables included in the matching equation significantly affect the process that places individuals into the treatment state of incarceration, the sample may not be homogenous, which could bias the parameter estimates or the substantive implications derived from the estimates.

Finally, there are tremendous complexities in understanding and unraveling the lives of individuals who are incarcerated. Many who end up in prison repeatedly spend their lives cycling through different correctional facilities, from prisons, to jails, to halfway houses, and often back again. Given the relative disadvantage of these individuals, some work speculates that time spent in prison may have some immediate—but not lasting—benefit to the most disadvantaged individuals (Schnittker and John 2007). It may be, for instance, that incarceration provides some short-term benefits by removing some individuals from abusive rela-

tionships or providing adequate nutrition. Definitive answers to these complex issues are beyond the scope of this research, but future research would be well served to focus on the health implications of repeated movement in and out of correctional facilities. In the end, rather than being the definitive statement on incarceration, stress, and infectious disease, the empirical results presented in this article should serve as a starting point for understanding how incarceration affects health.

In recent decades the scope of the correctional system has grown to the point where it now cuts a deep swath into many parts of con-

temporary American society. In light of this expansion, this article adds to a developed literature on the consequences of incarceration by examining the relationship between incarceration and health. The results indicate a relationship that cannot be attributed to either systematic differences between inmates and noninmates or to health problems evident before prison. Rather, the systematic pattern of illness suggests that exposure to infections and stressors associated with incarceration appear to be important factors in understanding the health-incarceration relationship.

APPENDIX. Logistic Regression Estimates of the Relationship between Health Problems and Incarceration Years (Model 1) and Health Problems and Both Incarceration Years and Incarceration Exposure (Model 2).

	Model 1			Model 2			
	Years		Overall Sample Prevalence	Years		Exposure	
	Est.	SE		Est.	SE	Est.	SE
Medical diagnoses							
Chronic lung disease	.410	(.04)***	3%	.010	(.06)	2.775	(.29)***
Nervous or psychological problems	.290	(.05)***	7%	.190	(.07)**	.756	(.37)**
Hypertension	.255	(.03)***	17%	-.007	(.05)	1.532	(.25)***
Heart problems	.119	(.07)*	3%	.041	(.10)	.533	(.49)
Arthritis	.052	(.05)	12%	—	—	—	—
Cancer	-.017	(.16)	2%	—	—	—	—
Diabetes	-.032	(.09)	5%	—	—	—	—
Self-reported conditions							
Urinary tract infections	.311	(.08)***	2%	.006	(.14)	2.410	(.60)***
Hepatitis or TB	.253	(.06)***	2%	.059	(.09)	1.631	(.48)***
Chest pain, heart problems	.133	(.05)*	6%	.012	(.17)	-.159	(.69)
Depression, excessive worrying	.187	(.04)***	12%	.138	(.64)*	1.631	(.48)**
General health problems	.056	(.05)	6%	-.082	(.08)	.825	(.34)**
Problems sleeping	.007	(.04)	15%	.009	(.06)	-.012	(.31)
Chronic headaches or dizziness	.032	(.05)	11%	-.066	(.08)	.569	(.36)
Epilepsy	.004	(.13)	1%	—	—	—	—
Skin problems	-.107	(.13)	3%	—	—	—	—
Allergies or frequent colds	.033	(.05)	24%	—	—	—	—
Tooth or gum problems	.001	(.06)	6%	—	—	—	—
Thyroid trouble	-.068	(.19)	3%	—	—	—	—
Back problems	-.048	(.04)	24%	—	—	—	—
Anemia	.012	(.12)	5%	—	—	—	—
Low blood pressure	-.019	(.11)	6%	—	—	—	—
Intestinal/gallbladder problems	-.064	(.06)	9%	—	—	—	—

* $p < .05$; ** $p < .01$; *** $p < .001$ (one-tailed tests)

Notes: N = 5,428. All models estimated separately controlling for race, gender, prior health problems, exercise frequency, self-reported weight, poverty status, employment status, alcohol consumption, cigarette use, and cohort dummy terms. Incarceration is measured as a continuous variable with a range of 0–14 years. For all health measures significant in earlier analysis (Tables 2 and 3 and Appendix model 1), model 2 further specifies the relationship between incarceration and health by including both a measure of length of incarceration and exposure to incarceration, demonstrating that exposure to incarceration is more consistently associated with health outcomes than with incarceration length. Model 2 was not estimated in cases where earlier analysis revealed no evidence of a relationship between incarceration and item-specific indicators of health.

NOTES

1. Cohort dummies capturing the survey year in which respondents answered the survey were used to test for any health differences based on when individuals answered the questionnaire. These survey year cohort dummies were not statistically significant.
2. I thank Jay Zagorsky and Steve McClaskie, NLSY user services, for their assistance in using the custom weighting program and constructing the weights.
3. Readers are encouraged to consult NLSY documentation for the precise wording on each question measuring health ailments. In some cases multiple ailments are grouped into a single question. Fortunately, only a few measured NLSY indicators—for instance, “chronic lung disease”—appear problematic when further specifying the relationship between incarceration and health. “Chronic lung problems” is a relatively vague term that, depending on the specific type of lung ailment, may be associated with stress (Horne and Picard 1979) or, in the case of the lung ailment tuberculosis, an infectious agent. Alternatively, lung disease is associated with smoking, and, given the ubiquity of the classification, it is problematic to link definitively to the hypothesis put forth in the article.
4. Depending on the specific matching algorithm, propensity scores can differ within a measured degree.
5. Version 2 is an add-on to STATA 8.0 that incorporates new options in the matching procedure.
6. The results were substantively consistent with using a radius matching procedure with a radius caliper of 0.01. Those interested in statistical and mathematical presentations of different matching estimators may consult Becker and Ichino (2002:5–7).
7. Given current debates (see Morgan 2001 or Dehejia and Sadek 2002) on the construction of matching equations, this analysis uses only interactions that are substantively relevant.
8. There is no evidence that individuals with prior health problems are more likely to be incarcerated. The propensity matching equation is a logit model, and the results indicate that prior health problems are a non-significant predictor of incarceration.
9. To assess the robustness of the matching equation, the analysis was estimated using alternative specifications. For instance, using years of schooling and labor force participation, rather than high school degree and current employment status, produced substantively similar results.
10. Reducing the sample composition through the matching process can inflate both parameter estimates and standard errors; therefore, the general consistency across methods, rather than an explicit comparison of parameter estimates, is most informative.
11. Of the more than 50 models run, there were three cases where the propensity models and the logistic models produced different results. Interestingly, they included two most common ailments: problems sleeping and chronic headaches, and one of the rarest, a diagnosis of heart problems. While this is clearly an area that warrants further investigation, given the number of models estimated, three false positives or false negatives could have occurred by chance.

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Michael Massoglia is Assistant Professor of Sociology and Crime, Law and Justice at The Pennsylvania State University. His research interests include crime and deviance over the life course, health stratification, and research methods. He is currently examining desistance during the transition to adulthood (with Christopher Uggen).