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Effects of chronic cocaine use on physical health: a prospective study in a general population sample[1]

Kevin Chen[a], Lawrence M. Scheier[b], Denise B. Kandel[c,*]

[a]*Department of Psychiatry, Columbia University, 722 West 168th Street, New York, NY 10032, USA*
[b]*Cornell University Medical College, New York, USA*
[c]*New York State Psychiatric Institute and Department of Psychiatry and School of Public Health, Columbia University, 722 West 168th Street, Box 20, New York, NY 10032, USA*

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Abstract

Few studies have examined long-term effects of chronic cocaine use on physical health in the general population. The current study assesses the effects of chronic cocaine use by the late twenties on physical health by the mid thirties in a longitudinal cohort from the general population. Measures of physical health included self-reported health status, cardiovascular, neurological, and somatic symptoms, and number of hospital or sick days within the last year. The causal analyses were restricted to males because few females used cocaine heavily and the relationships between females' cocaine use and physical health were rarely significant. Among males, chronic cocaine use increased physical health problems, controlling for prior health status, current cocaine use, use of other drugs and sociodemographic characteristics. In turn, poor health contributed to continued cocaine use. Variance partitioning based on cocaine use patterns (frequency and chronicity) indicated that chronic users experienced the most adverse consequences on subsequent physical health. Implications for understanding how chronic cocaine use affects a broad spectrum of physical functioning are discussed.

Keywords: Cocaine; Physical Health; Consequences; Adults; Longitudinal

1. Introduction

Cocaine use has been found to be associated with many negative health consequences and medical complications in clinical and treatment samples (Chitwood, 1985; Washton and Gold, 1984; Bunn and Giannini, 1992; Perper and Van Thiel, 1992a,b; Weiss et al., 1994). These consequences are reflected in national morbidity and mortality statistics. As recently as 1994, 28% of all drug-related emergency room visits in the US were related to the use of cocaine or crack (SAMHSA, 1995a). The highest rates of cocaine-related emergency room episodes were observed among males in their mid-twenties to early-thirties. The rate for those aged 26–34 was 165.8 per 100 000, almost twice the rate (89.6%) observed at ages 18–25 (SAMHSA, 1995a: p. 92). Since 1989, about 50% of drug-related deaths in medical examiner reports have implicated cocaine (SAMHSA, 1996a). Despite these statistics, few epidemiological studies in the general population have clearly documented that cocaine use has a significant negative effect on physical health; most studies have found few or small significant effects (for reviews, see Newcomb et al., 1987; White and Bates, 1993). The studies that have reported an association between cocaine use and health problems have been based on cross-sectional samples in which no clear causal relationship can be established (Erickson et al., 1994; Keer et al., 1994; Newcomb and Bentler, 1987a; White and

* Corresponding author.

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Bates, 1993), or report a significant longitudinal effect on psychological but not physical symptoms (Anthony and Petronis, 1991; Newcomb et al., 1993).

1.1. Acute and long-term physical complications from cocaine use

Despite its initial euphoriant effects, the use of cocaine can have serious medical and physical complications. Much of the documentation regarding these adverse consequences has been gathered from autopsies of decedent cocaine users (Mittleman and Wetli, 1984), cocaine abusers seeking drug treatment (Chitwood, 1985; Cregler, 1991) or contacting a national cocaine hot-line (Gold, 1993; Washton and Gold, 1984), drug-related admissions to hospital emergency rooms (SAMHSA, 1995a), and general population studies of those with self-reported drug problems (Castro et al., 1988; Erickson et al., 1994; Keer et al., 1994; Newcomb and Bentler, 1987a, 1988; Waldorf et al., 1991; White and Bates, 1993).

Acute effects of cocaine use include dilated pupils, changes in body temperature, sleep disturbances, cardiovascular symptoms, nasal sores (Bunn and Giannini, 1992; Chitwood, 1985; Perper and Van Thiel, 1992a; Nademanee, 1992; Washton and Gold, 1987; Waldorf et al., 1991), respiratory problems (Perper and Van Thiel, 1992b), neurological impairment, and psychiatric problems (e.g. nervousness, psychoticism, depression and suicidal ideation) (Cregler, 1989; Waldorf et al., 1991). Long-term effects associated with cocaine use noted in the medical literature include neurological (Pascual et al., 1991), gastroenteric (Van Thiel and Perper, 1992), obstetric (Chasnoff, 1991; Chasnoff et al., 1985), and cardiologic (Cregler, 1991; Goldfrank and Hoffman, 1991; Gordon and Thompson, 1987) complications. Despite compelling evidence of medical complications, Kosten et al. (1988) reported that cocaine-using opioid addicts enrolled in multiple treatment modalities, who increased their use during the two-and-a-half year follow-up period, reported the fewest medical problems although they reported extensive psychosocial problems.

The negative health consequences usually observed in clinical samples contrast with the lack of effects observed in general population samples. Epidemiological studies based on self-reports of health status have not provided compelling support for a strong relationship between cocaine use and physical problems (see Newcomb et al., 1987; White and Bates, 1993), although some significant associations have been reported. White and Bates (1993) examined the self-attributed effects of cocaine use in a community sample of adolescents and young adults (aged 15–21) followed over three years. Intensity of cocaine use was a better predictor of negative symptoms (passed out or fainted suddenly and had the shakes) than duration. Newcomb and Bentler (1987a) found that at ages 19–24 years male and female cocaine users reported poorer health than non-users, based on a multi-item assessment of physical health functioning (15 items tapping self-reported health, physician and hospital utilization, and severity of illness). Male users also reported greater physician and hospital utilization, whereas females were more likely to report contracting a venereal disease or having an abortion. Because these studies did not control for baseline health status, it is difficult to establish links between cocaine use and subsequent health problems. However, Castro et al. (1988) examined the effects of cocaine on mental and somatic health problems in the same sample of adolescents (Newcomb and Bentler, 1987a) over a four year interval. Controlling for earlier health status, intensity of cocaine involvement in adolescence did not significantly predict health problems four years later.

Most youth and adolescents use cocaine "to feel good", "have fun", "have a good time with friends" or "for more energy" (O'Malley et al., 1985). For casual or recreational users, the use of cocaine may not become problematic until use becomes more regular or chronic. Indeed, in a snowball sample of cocaine users who continued to use cocaine, early pleasurable experiences tended to give way to somewhat more negative ones, including physical and psychological problems (Waldorf et al., 1991).

1.2. Methodological and conceptual problems in studying the effects of cocaine use

A number of methodological problems affect the interpretation of results reported in the literature. As noted above, the few studies that have reported long-term effects of cocaine use have relied mostly on treatment and clinical samples. These samples, however, may be subject to various selection biases. Those presenting for treatment are more likely to present co-morbid symptomatology (Ford et al., 1989; Mirin et al., 1988) and their behavior is likely to include more chronic use than those not in treatment (Nunes et al., 1989). There may also be a self-reporting bias, since individuals seeking drug treatment recognize that they have a substance abuse problem and may be more likely to report related health problems (Gorelick, 1990). A study of a general population sample may eliminate these biases.

Previous studies of cocaine use in general population samples have several limitations. In many cases, the use of cross-sectional data limit causal inferences (Erickson et al., 1994; Newcomb and Bentler, 1987a). In the absence of controls for prior health status or other factors, it cannot be demonstrated that cocaine use is responsible for the changes in health status. Physical

health problems observed among heavy cocaine users may not be due to cocaine, but to differences in lifestyles and other harmful behaviors that differentiate cocaine users from non-users (Brunswick, 1988; Brunswick and Messeri, 1986; Castro et al., 1987; Kandel et al., 1985; Kandel and Davis, 1991; Weiss et al., 1994). Longitudinal design or fixed-effect models are needed to reveal the causal relationships between cocaine use and health problems. Furthermore, observations made in the general population may not have been conducted over long enough periods of time or at the appropriate phase of the life-span to identify the true effects of cocaine use. Most studies have focused on samples of adolescents and young adults when cocaine is first initiated and used most frequently. Cross-sectional or short-term follow-up studies may not capture the possible negative physical health consequences of cocaine use, which may take some time to become manifest (Newcomb et al., 1993). Because young drug users are at the peak of their physical health they may not yet experience the adverse consequences of use. The effects of cocaine use on users' physical health, if any, may not be immediately observable, and may appear later in adulthood. It is necessary to follow individuals over an extended time period to identify the potential long-term health effects of cocaine use. Age may play an important role in the study of the relationship between cocaine use and health. Since the period of maximal use in the general population occurs between ages 25–35, it is important to include these years in the study of the health effects of cocaine.

1.3. Research questions

The generally contradictory findings between research based on selected as opposed to population samples led us to explore further the relationship between cocaine use and physical health in a general community sample. Because heavy users are part of the population, the negative effects of cocaine on physical health observed among clinic or treatment samples are likely to be observed in general population samples.

In this study we address several shortcomings of previous studies of cocaine use in the general population. We follow young people over time through their mid-thirties, and control for earlier health status and other characteristics. In addition, we examine the changes in physical health problems among cocaine users and non-users over six years from age 28–29 years to age 34–35 years, taking into account the respondents' prior cocaine history and current use patterns. Our goal is to identify the potential long-term impact of cocaine use on individuals' physical health as they age from their twenties to their mid-thirties. In addition, we examine the potential role of lifestyle differences in accounting for the relationship between cocaine use and health problems as well as changes in individuals' physical health. The period in the life cycle under study corresponds to high rates of cocaine use (Johnston et al., 1993; SAMHSA, 1995b) and the highest rate of cocaine-related emergency-room admissions (SAMHSA, 1995a).

This study addresses two primary research questions: (i) in addition to acute physical health problems, does cocaine use have long-term adverse effects on physical health that result from chronic use? and (ii) do lifestyle factors and a tendency toward multiple drug use account for the effects of cocaine use? Longitudinal structural equation models with latent variables were estimated to address these questions and examine the effects of cocaine use on concurrent and subsequent physical health. Structural equation modeling represents a powerful analytic tool for elucidating developmental relations (Rogosa, 1979). Physical health was conceived as multidimensional and a diverse set of indicators were used to map the broad spectrum component of behaviors and experiences (Newcomb and Bentler, 1987b; Steiner and Norman, 1989). Multiple indicators of physical health including cardiovascular, neurological, and somatic physical symptoms, self-reported health, and number of reported hospital or sick days were used to reflect a dimension of health problems. We also used variance partitioning methods to identify the effects of different patterns of cocaine use on health functioning. These analyses focused on effects in the late-twenties and mid-thirties, when emergency room data suggest that cocaine-related morbidity reaches a peak.

2. Data and methods

2.1. Sample

The analyses are based on a follow-up cohort last interviewed at age 34–35 years in 1990 (532 males, 620 females). The original sample was a probability sample of adolescents enrolled in public secondary schools (grades 10 and 11) in New York State in the fall of 1971. The two-stage sampling procedure involved the selection of a stratified sample of 18 high schools and a sample of students clustered by homerooms and stratified to represent the different grades within each school. Students who had not participated in the initial study, and presumably were chronic absentees, were also selected at the time of the first adult follow-up to permit unbiased estimates of the former student population.

Three adult follow-ups were carried out in 1980, 1984, and 1990. With a completion rate of 81% of those living, 1325 persons were interviewed in 1980, at the mean age of 24.7. Four years later in 1984, 1222

persons, comprising 92.5% of the 1980 sample (excluding four deceased), were reinterviewed at age 28–29 years. Of these participants, 1160 were reinterviewed in 1990 at age 34–35 years, with a completion rate of 95.7% (excluding ten deceased persons). Overall, 71.7% of the initial adolescent target sample still alive was reinterviewed in 1990.

Data were obtained through structured personal household interviews that took on average 90 min to administer. The interview schedule consisted almost exclusively of structured items with closed-end response alternatives and two charts designed to reconstruct the respondent's life and drug histories on a monthly basis. Drug histories were obtained from respondents who reported to have used each drug ten times or more in their lives so as to exclude experimental or infrequent use. At each follow-up survey, information was collected on respondents' health status. Sampling weights took into account all relevant features of the sampling design and adjusted for the differential participation of the target follow-up sample in each survey.

2.2. Measures

2.2.1. Health problems

At each wave, health problems were measured by five indicators tapping physical symptoms, self-reported health, and number of sick or hospital days. Three multi-item scales measured cardiovascular, neurological, and general somatic symptoms. These health symptom indicators were weighted mean composites derived from 16 items taken mainly from the SCL-90-R (Derogatis, 1983)[2]. Subjects were provided with a stem asking how much a particular problem had bothered or distressed them during the last 12 months. A five-point response format ranged from 'not at all' (0) through to 'extremely' (4). A single item tapped self-reported health status ("how would you rate your health") with responses ranging from 'excellent' (1) through to 'poor' (5). Number of days sick in bed or in the hospital in the past 12 months were combined into a single indicator. A logarithm transformation was used to normalize the distribution of this highly skewed measure.

In the longitudinal structural equation models, these five measures of physical health were used to reflect a latent construct of health problems, scaled toward greater problems. In the variance partitioning analysis, the observed measures were analyzed separately. A mean symptoms score for each domain was calculated by dividing the weighted sum of items for each cluster by the number of items in that cluster. In addition, a total symptom score added the total number of symptoms experienced at least moderately, i.e. scores 2, 3 or 4.

2.2.2. Use of cocaine and other drugs

Latent constructs for cocaine use and multiple drug use were defined at each wave and included in two separate models: one model specified chronic cocaine use and a second model specified multiple drug use, and included an indicator of cocaine use. For both models, the 1984 construct measured cumulative drug behavior from adolescence to 1984; the 1990 construct measured drug behavior in the six years between the 1984 and 1990 surveys.

In 1984, the latent construct of cumulative and chronic Cocaine Use was reflected by four indicators: frequency of use in the past 12 months—ranging from 'no use' (0) to 'daily use' (8)—in 1980 and 1984; number of months used cocaine at least once a month between the inception of the study in 1971 and 1984, based on the cumulative monthly drug histories (converted to number of years); and age of onset, ascertained in 1980 and in 1984. In 1990, the latent construct of cocaine use was reflected by two manifest indicators: frequency of cocaine use in 1990 and number of months used at least once a month since 1984 (converted into years).

In a subsequent model, the latent construct of multiple drug use was reflected by variables measuring duration and frequency of use of four classes of drugs. In 1984, the four indicators included years of near-daily alcohol use, daily cigarette smoking, marijuana and cocaine use at least once a month for the 13-year interval between age 15–16 years (1971) and age 24–25 years (1984). In 1990, the four indicators included the same four drug use behaviors for the interval between 1984 and 1990.

2.2.3. Sociodemographic characteristics

The demographic variables were measured in 1984 and included highest year of schooling completed (9–20); current marital status (1 = married, 0 = other); and family income (mid-point of 14 precoded categories of annual earnings in thousand dollars, range from 2 to 85).

2.3. Analytic strategies

As a first step, we examined gender differences in cocaine use patterns and physical health symptoms. As a second step, to identify the potential effect of cocaine use on physical health, two-wave structural equation

[2] The 16 items represented three groups of symptoms. (a) Cardiovascular symptoms: (1) pains in the heart or chest; (2) trouble getting breath; (3) heart pounding or racing; (b) Neurological symptoms: (4) headaches; (5) faintness or dizziness; (6) numbness or tingling in parts of body; (7) hands trembling; and (c) general somatic symptoms: (8) nausea or upset stomach; (9) soreness of muscles; (10) hot or cold spells; (11) feeling weak in parts of body; (12) constipation; (13) heavy feelings in arms or legs; (14) ulcers; (15) sore throat or hoarse voice; (16) sexually transmitted diseases, herpes or gonorrhea.

models (SEM) with latent variables were estimated using the EQS statistical program (Bentler, 1993). In the first model, physical health at age 34–35 (in 1990) was predicted by the same measure at age 28–29 (in 1984) and by a latent construct of cocaine use that captured chronic and cumulative cocaine use from age 15–16 years (1971) onward. Cocaine use in 1990 was also included to take into account the effect of continued cocaine use on current health. Also included were controls for sociodemographic factors (income, marital status, and education). Subsequently, we tested a second model which estimated the effects of multiple drug use during the same period, (i.e. duration of frequent cigarette, alcohol, marijuana, and cocaine use) on later health functioning. Because most cocaine users also use other drugs that may affect their health, this procedure maximized the specificity of the estimation of the cocaine effect and through the estimation of nonstandard effects segregated the cocaine effect from the potential effects of other drugs. Since both demographic factors and multiple drug use have been shown to influence physical functioning and cocaine use, failure to include controls for these sources of variance in the model would likely bias the regression statistics. However, a model restricted to cocaine use was estimated first in order to identify the maximum effect attributable to cocaine use and to estimate the unique effects of the manifest indicators.

Determination of S.E.M. model fit was based on several key statistics: the significance of the model χ^2 ($P > 0.05$, a non-significant P-value indicates that the sample data are a reasonable approximation to the hypothetical structure; the comparative fit index (CFI: Bentler, 1990), a sample-size adjusted analogue to the Bentler-Bonett normed fit index (Bentler and Bonett, 1980), with values greater than 0.90 considered adequate; and the ratio of χ^2/df, with suggested ratios less than 5.0 indicating a good model fit (e.g. Marsh et al., 1988).

Finally, to provide a description of the relationship between cocaine use and physical health, we partitioned variances among the physical health symptoms for males on the basis of categorical levels of cocaine use, controlling for sociodemographic variables.

3. Results

3.1. Gender Comparisons

Summary descriptive statistics for the measures used in the analyses are presented in Table 1 for males and females. Several measures were moderately skewed (mostly the single item drug use measures) and non-normally distributed. However, these moments were comparatively small and should not strain the robustness of the maximum-likelihood estimation methods used in the structural equations portion of the analyses (Bentler, 1993).

Males and females differed significantly in their cocaine use. Twice as many males as females (28.7% versus 14.0%) had ever used cocaine. Males had used cocaine more frequently and for a longer period than females. Only 6.2% of females reported having used cocaine within the last year at age 24–25 years, 6.5% at age 28–29 years and 2.8% at age 34–35 years. Corresponding percentages for males were two to three times higher, 12.6%, 16.5% and 6.2%, respectively. By age 28–29 years, among cocaine users the mean total number of months of cocaine use was 23 months for males versus 13 months for females ($t = 2.80$, $P < .01$); 25.6% of male users versus 9.4% of female users had used cocaine 100 times or more in their lifetime [$\chi^2(2) = 10.1$, $P < .01$)].

Females reported significantly more health problems than males at each assessment for neurological symptoms, hospitalization, and sick days. Females were also more likely to report more somatic symptoms and poorer health at age 34–45 years. There were no significant gender by cocaine user status interaction effects on health problems in a multivariate analysis of variance (data not shown but available from authors).

3.2. Associations between cocaine use and physical health

Zero-order Pearson correlations between the cocaine use and physical health indicators at each assessment are presented for males and females in Table 2. For females, the magnitude of the bivariate associations were consistently small and nonsignificant. The low magnitude of the associations may be attributed to the females' infrequent and low intensity of cocaine use, as well as to gender differences in physiological reactions to cocaine (Lukas et al., 1994).

In contrast to the female data, the associations between cocaine use and physical health among males were substantially larger in magnitude, and a greater number of these relations achieved significance. Furthermore, among males the magnitude of the contemporaneous associations increased over time. At age 24–25 years, these associations were quite low (only three of the 15 associations were significant). At age 28–29 years, the co-variations among these indicators strengthened considerably (eight of the 15 observed associations were significant); frequency of cocaine use was significantly and positively associated with each physical health indicator. By age 34–35 years, 14 of the 15 associations were significant; the magnitudes of these relationships were substantially larger than 6 years earlier, indicating a growing consolidation of these behaviors across time.

Longitudinal associations between cocaine use and physical health problems suggest time-lagged and age-related negative health consequences of cocaine use

Table 1
Descriptive statistics for selected variables

Variables	Number of items	Range	Males			Females		
			Mean	S.D.	Skewness	Mean	S.D.	Skewness
Age 28–29 years (1984)								
Cocaine Use								
Years since first use	1	0.0–15.6	1.54	3.17	2.08	0.66	2.11	3.55
Use frequency in 1980	1	0.0–8.0	0.42	1.25	3.47	0.17	0.75	5.14
Use frequency last year	1	0.0–8.0	0.51	1.32	2.90	0.20	0.84	4.65
Number of years used 1971–84[a]	1	0.0–13.0	0.56	1.76	3.80	0.16	0.75	6.50
Health Indicators								
Cardiovascular symptoms	3	0.0–3.33	0.33	0.47	2.09	0.31	0.47	2.08
Neurological symptoms	4	0.0–2.75	0.39	0.41	1.54	0.56	0.49	1.55
General somatic symptoms	9	0.0–2.11	0.42	0.34	1.46	0.46	0.34	1.36
Total count of physical symptoms[b]	16	0.0–14.0	1.34	2.01	2.38	1.83	2.21	1.81
Self-reported health	1	1.0–5.0	1.71	0.73	1.46	1.69	0.63	0.74
Number of days in bed/hospitalization[c]	2	0.0–5.34	0.82	0.91	1.14	0.95	0.98	0.94
Other Drug Use by 1984								
Years smoking daily 1971–84[a]	1	0.0–13.1	3.64	4.53	0.86	3.22	4.27	1.02
Years drinking 4+times/week 1971–84[a]	1	0.0–13.1	2.42	3.80	1.56	0.76	2.05	3.46
Years using marijuana 1971–84[a]	1	0.0–13.1	4.35	4.75	0.57	2.51	3.73	1.31
Social Demographic in 1984								
Years of schooling	1	9.0–20.0	13.94	2.24	0.53	13.91	2.28	0.73
Currently married	1	0.0–1.0	0.52	0.50	−0.09	0.59	0.49	−0.35
Annual family income ($1,000)	1	2.0–85.0	33.22	18.00	1.00	30.50	17.56	0.83
Age 34–35 years (1990)								
Cocaine Use								
Use frequency last year	1	0.0–8.0	0.20	0.93	5.77	0.08	0.60	9.92
Number of years used 84 90[a]	1	0.0–5.50	0.19	0.82	4.87	0.08	0.50	8.01
Other Drug Use between 1984–1990								
Years smoking daily[a]	1	0.0–6.2	1.86	2.56	0.71	1.55	2.37	1.00
Years drinking 4+ times/week[a]	1	0.0–6.1	1.05	2.05	1.62	0.24	1.00	4.53
Years using marijuana[a]	1	0.0–6.2	0.83	1.87	1.97	0.28	1.12	4.12
Health Indicators								
Cardiovascular symptoms	3	0.0–3.00	0.36	0.49	1.94	0.33	0.49	2.16
Neurological symptoms	4	0.0–3.75	0.39	0.44	2.70	0.57	0.47	1.47
General somatic symptoms	9	0.0–3.11	0.45	0.37	2.43	0.49	0.37	1.45
Total count of physical symptoms[b]	16	0.0–15.0	1.51	2.15	2.53	2.00	2.30	1.50
Self-reported health	1	1.0–5.0	1.72	0.71	1.54	1.79	0.70	1.00
Number of days in bed/hospitalization[c]	2	0.0–5.28	0.66	0.91	1.64	0.89	0.99	1.15

Weighted sample; male = 532, female = 620.
[a] Number of months when used at least once a month, divided by 12.
[b] Counts of total number of moderate or more serious symptoms.
[c] Based on logarithm transformation: ln(number of sick days+1).

among males. There was only one significant association over the four-year interval between cocaine use at age 24–25 years (1980) and the physical health indicators at age 28–29 years (1984). By contrast, nine of the 15 associations spanning the ten-year interval between the mid-twenties (1980) and mid-thirties (1990) and 12 of the 15 associations over the six-year interval between ages 28–29 years and 34–35 years (1984–1990) were significant. Both frequency of use and number of years cocaine was used since adolescence were substantially and significantly related to the five indicators of physical health in 1990. These associations provide a clearer picture of the longitudinal relationships between cocaine use and physical health: negative effects increase over time and appear to be time-lagged.

3.3. Longitudinal models of cocaine use and physical health

The low prevalence of cocaine use among women, the infrequent pattern of use and the lack of significant associations between health problems and cocaine use precluded the estimation of causal models among women. Using only the male data, we first tested a

Table 2
Correlation coefficients between cocaine use and health indicators from age 24–25 years (1980) to age 28–29 years (1984) and age 34–35 years (1990) (males $n = 532$; females $n = 620$)

	Age 24–25 years (1980)			Age 28–29 years (1984)			Age 34–35 years (1990)		
Health	*AGE ONSET*	*COCFREQ*	*YRUS71–80*	*COCFREQ*	*YRUS80–84*	*YRUS71–84*	*COCFREQ*	*YRUS84–90*	*YRUS71–90*
Males									
1980									
CV-M	0.047	0.073	0.067	0.150**	0.114**	0.099*	0.121**	0.102*	0.118**
NERV-M	0.012	0.112**	0.090*	0.105*	0.165**	0.139**	0.140**	0.111*	0.152**
GEN-M	0.005	0.098*	0.072	0.107*	0.138**	0.114**	0.132**	0.106*	0.131**
HEALTH	0.043	0.033	0.072	0.007	0.011	0.057	0.053	0.089*	0.079
SICKDAY	−0.019	−0.019	−0.067	0.073	0.018	−0.040	−0.051	−0.019	−0.039
1984									
CV-M	−0.028	−0.055	−0.034	0.131**	0.032	−0.010	0.028	0.041	0.008
NERV-M	−0.071	0.006	−0.014	0.107*	0.075	0.023	0.139**	0.129**	0.067
GEN-M	−0.038	0.015	0.045	0.135**	0.136**	0.094*	0.102*	0.124**	0.121**
HEALTH	0.038	0.032	0.085*	0.129**	0.065	0.091*	0.055	0.027	0.083
SICKDAY	0.004	0.040	0.037	0.114**	0.063	0.055	0.049	0.029	0.055
1990									
CV-M	0.075	0.096*	0.098**	0.102*	0.125**	0.127**	0.174**	0.171**	0.165**
NERV-M	−0.008	0.138**	0.109**	0.071	0.127**	0.135**	0.218**	0.205**	0.185**
GEN-M	0.051	0.145**	0.157**	0.100*	0.160**	0.185**	0.213**	0.231**	0.234**
HEALTH	0.080	0.095*	0.152**	0.061	0.046	0.131**	0.062	0.092*	0.139**
SICKDAY	0.059	0.090*	0.079	0.107*	0.108*	0.106*	0.135**	0.099*	0.121**
Females									
1980									
CV-M	0.079	0.037	0.046	0.039	0.012	0.044	−0.011	-0.026	0.020
NERV-M	0.051	−0.001	−0.022	0.100*	0.036	0.002	−0.063	−0.035	−0.016
GEN-M	0.082*	0.007	0.003	0.023	−0.014	−0.005	−0.039	−0.001	−0.004
HEALTH	0.036	−0.012	0.014	0.013	−0.005	0.008	−0.004	0.049	0.031
SICKDAY	0.061	0.037	0.005	−0.009	−0.007	−0.000	0.004	−0.031	−0.016
1984									
CV-M	0.041	−0.009	−0.004	0.095*	0.001	−0.002	−0.015	0.008	0.002
NERV-M	−0.012	−0.019	−0.014	0.087*	0.130**	0.060	0.104**	0.117**	0.105**
GEN-M	−0.016	−0.049	−0.006	0.060	0.051	0.022	0.039	0.087*	0.061
HEALTH	0.069	0.004	−0.010	0.064	0.043	0.015	0.019	0.057	0.040
SICKDAY	0.083*	0.051	0.051	0.113**	0.104**	0.099*	0.087*	0.078	0.115**
1980									
CV-M	0.004	−0.013	0.064	−0.022	−0.017	0.043	−0.058	−0.043	0.011
NERV-M	−0.037	−0.042	−0.031	0.011	0.019	−0.014	−0.024	−0.021	−0.021
GEN-M	−0.042	−0.050	−0.039	−0.019	−0.026	−0.046	−0.047	−0.017	−0.043
HEALTH	0.044	0.006	−0.003	0.001	−0.024	−0.016	0.071	0.092*	0.035
SICKDAY	0.018	−0.009	−0.014	−0.003	0.004	−0.009	0.115**	0.059	0.023

Labels of health indicators: CV-M, mean cardiovascular symptoms; NERV-M, mean neurological symptoms; GEN-M, mean general physical symptoms; HEALTH, self-reported health status; SICKDAY, logged (# sick days + 1) last 12 months.
Labels of cocaine use measures: AGE ONSET, reversed age of onset, i.e. years since first use; COCFREQ, frequency of cocaine use last year; YRUS71–80, years used cocaine monthly from 1971–80; YRUS80–84, years used cocaine monthly from 1980–84; YRUS71–90, years used cocaine monthly from 1971–90.
* $P < 0.05$; ** $P < 0.01$.

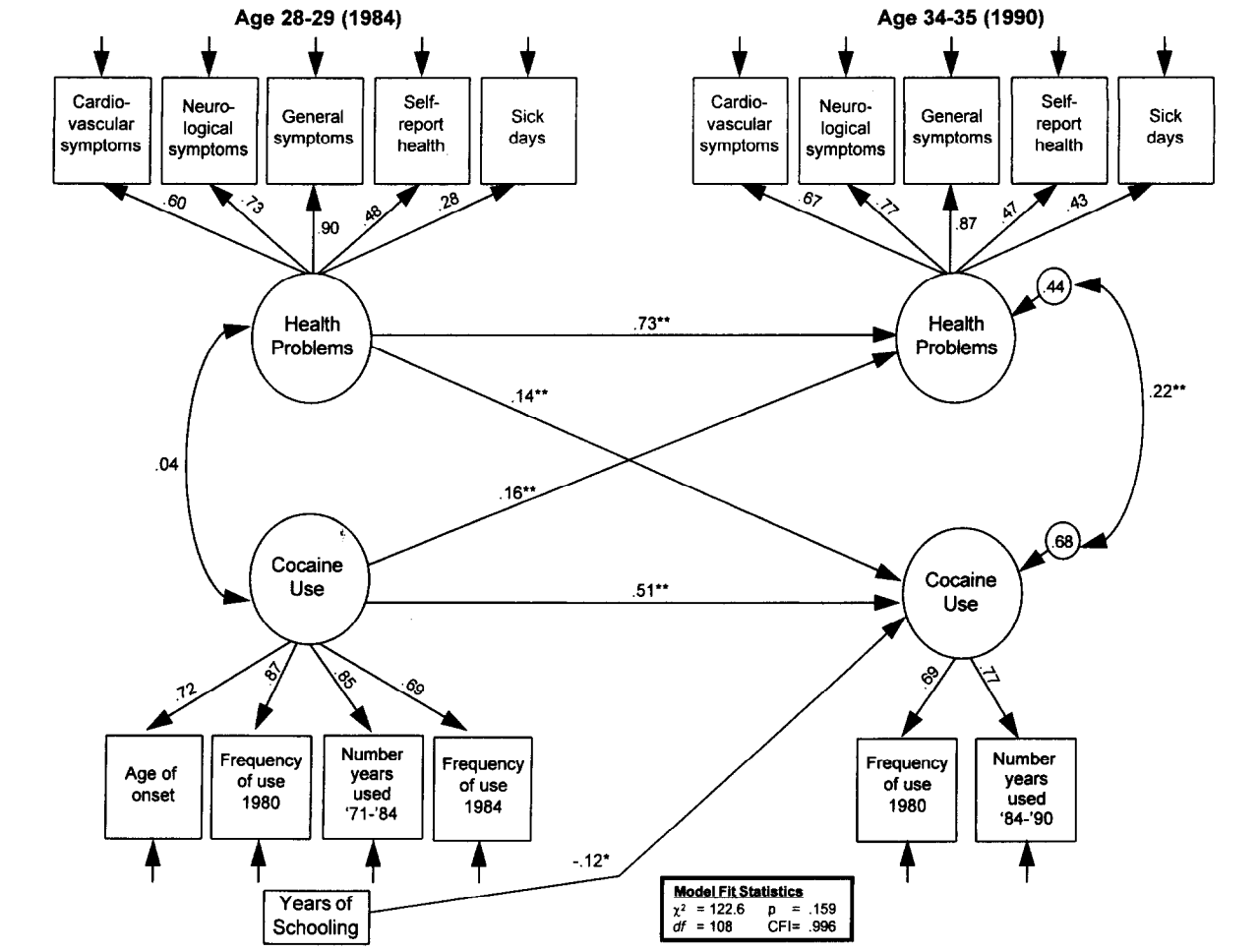


Fig. 1. Causal model of cocaine use and health problems from age 28–29 years to age 34–35 years (male sample, $n = 532$).

two-wave panel model that included four latent factors: prior health problems by age 28–29 years, current health problems at age 34–35 years, cumulative cocaine use by age 28–29 years, and cocaine use between ages 28–29 years and 34–35 years. This model estimated the effect of chronic cocaine use on change in health status during the follow-up interval, controlling for earlier health status and current cocaine use in a cross-lagged panel design.

The specification of a latent construct of chronic cocaine use in 1984 captured chronic and cumulative use of cocaine as of adolescence (1971). As noted above, the pattern of correlations depicted in Table 2 revealed an increasing consolidation of behavior over time. The increased magnitude of associations by age 34–35 years supports a chronic or delayed effect hypothesis. We hypothesized that the longer the duration of use and the more frequent the use between assessments, the more likely are negative health symptoms to be reported at a later time period. Cocaine use in 1990 further captured continued and chronic use by the mid-thirties. The overall specification of the model followed the estimation of a three-wave path model that proved to be statistically unstable[3]. Fig. 1 displays the results of the longitudinal structural model for males.

[3] In a series of analyses not reported here, we tested other 2-wave and 3-wave models. We tested two separate 2-wave models in which current cocaine use at the first interval predicted health problems at the second assessment (1984), controlling for initial health problems. One model predicted health problems from 1980 (age 24–25 years) to 1984 (age 28–29 years); the second model predicted health problems from 1984 to 1990. In neither model was the path from cocaine to health significant. (In these models, cocaine use in 1984 was measured by frequency of use in 1984 and number of years used between 1980 and 1984. This is in contrast to the present model, where the measure of cocaine use in 1984 incorporates chronicity of use, including use in 1980 and duration since 1971.) We also estimated a more traditional 3-wave panel model that specified measures of cocaine and health in 1980, 1984 and 1990, but we were unable to obtain stable regression estimates. A close inspection of the residual matrices and the parameter estimates obtained from the 3-wave models revealed counterintuitive regression effects. In the 2-wave model, for the period corresponding to 1984–1990, cocaine use in 1984 increased physical health problems in 1990, although the effect was not statistically significant. However, in the 3-wave model, cocaine use in 1984 significantly decreased physical health problems in 1990, controlling for earlier health and cocaine use. The negative relation between

Circles represent latent constructs and rectangles measured variables; small circles with numbers represent residual disturbances that reflect variances unaccounted after prediction. We also statistically controlled for three sociodemographic measures (income, years of schooling, and marital status). Only significant paths are depicted in the figure. Factor loadings from the measurement model are standardized, and in the structural portion of the model, path coefficients represent standardized partial regression effects. Several within-time associations among the manifest indicators and significant across-time residual covariances were taken into account in the estimation procedure but are not shown. Model fit statistics indicate an adequate fit— $\chi^2(108,\ n = 532) = 122.6,\ P = 0.16,\ \chi^2/\mathrm{df} = 1.14$, comparative fit index (CFI) = 0.996.

The measurement portion of the model indicates that we have appropriately conceptualized the latent constructs of cocaine use and physical health. Standardized loadings on the manifest indicators from all the latent constructs are large and significant, indicating reliable and psychometrically sound indicators. Physical health both in 1984 and 1990 is strongly indicated by physical symptoms and less so by number of sick or hospital days. Parameter loadings for cocaine use were equal in magnitude, supporting the high interrelation of risk deriving from frequency of prior and current use, early onset, and total duration of use over time.

Associations among the sociodemographic measures, cocaine use, and physical health at age 28–29 years showed a few, albeit small, relations. The largest association was between family income and education ($r = 0.23,\ P < 0.01$). Overall, sociodemographic measures were not significantly associated with the latent cocaine use construct; however, marital status and education were significantly associated with fewer health problems ($-0.15,\ P < .01$ and $-0.10,\ P < .05$, respectively).

The structural regression paths confirm that cumulative and chronic cocaine use adversely influenced physical health. After controlling for stability in physical health ($\beta = 0.73,\ P < 0.01$), cumulative cocaine use by 1984 increased physical health problems over the six-year interval from 1984 through 1990 ($\beta = 0.16,\ P < 0.01$). The lagged effect from health problems to cocaine use was also significant: those who had poorer health were more likely to continue using cocaine. At age 34–35 years, the contemporaneous association between health problems and cocaine use is also highly significant. By contrast, at age 28–29 years (1984), health problems and cumulative cocaine use were unrelated ($r = 0.04$). The lack of significant contemporaneous relation between these two (1984) constructs in the path model is partially explained by the absence of any sizeable zero-order associations between three of the four manifest indicators for the latent construct of cocaine use and the health indicators in 1984 (See Table 2). The significant correlations between the fourth indicator, i.e. frequency of cocaine use in 1984, and health problems were captured by the correlated residuals (not shown in the figure).

The fit of the basic model in Fig. 1 reflects the inclusion of correlated residual error terms within-time and nonstandard regression paths (largely between across-time repeated measures) that are not depicted for clarity. Within-time associations between frequency of cocaine use and all of the indicators of physical health were highly significant (data not shown). Empirical modification indexes (Chou and Bentler, 1990), which indicate the overall change in the fit of the model (decrement in χ^2) with the relaxation of specific constraints, guided the inclusion of several nonstandard parameters. To simplify the figure, these are not depicted since only one involved the effect of the manifest indicators of cocaine use on health[4].

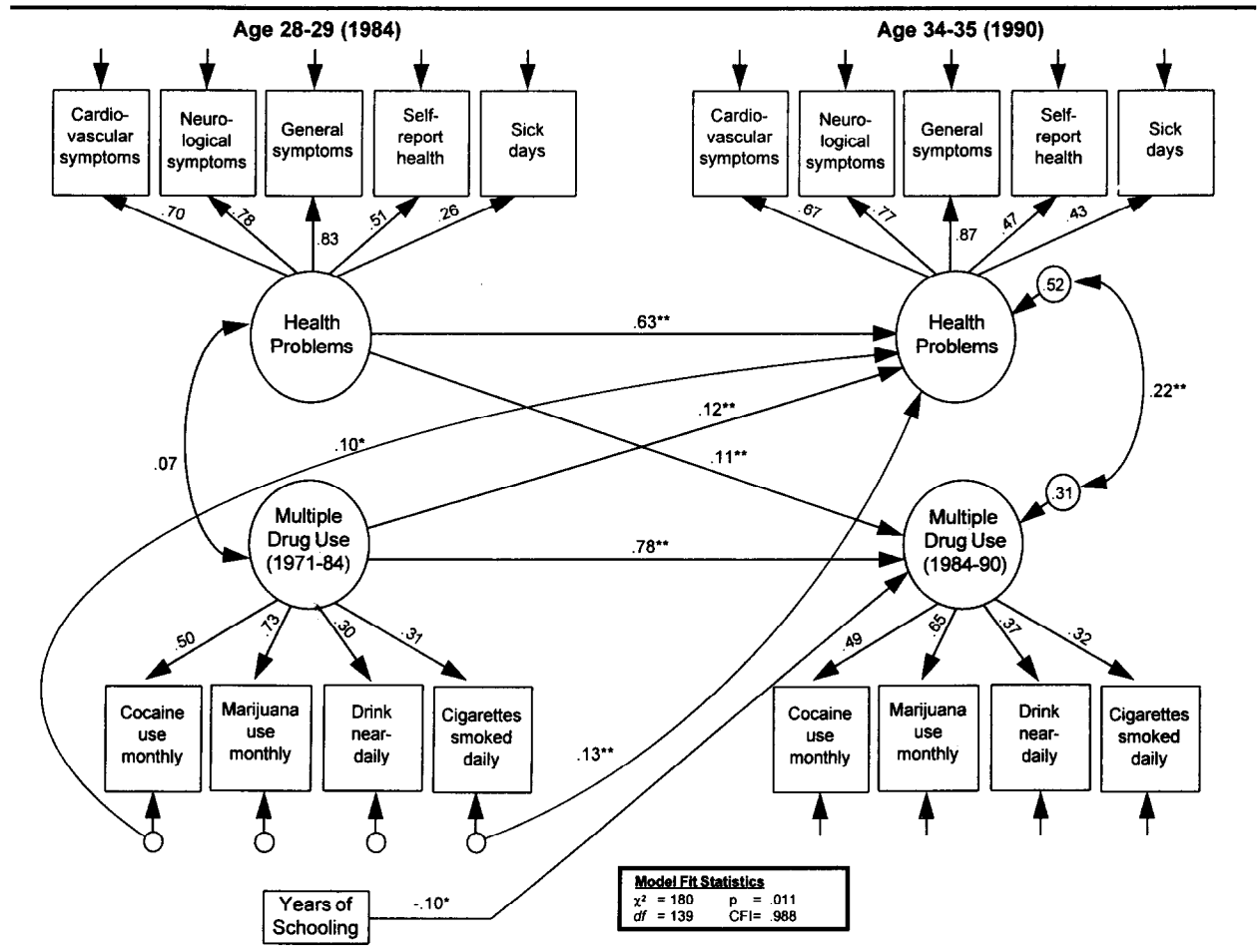
3.4. Controlling for the use of other drugs

Other factors, in addition to those already considered, may be related to decrements in physical functioning. As previously mentioned, cocaine users may be differentiated on the basis of lifestyle factors including multiple drug use, nutritional care, exercise, and related determinants of overall health functioning. Controlling for the use of other drugs is especially important because most cocaine users have used other drugs, which may also cause serious health problems. Among the 140 males who had used cocaine at least ten times by age 28–29 years, 83.8% had ever smoked cigarettes at least ten times, 100% had drunk alcohol at least 100 times, and 99.7% had ever used marijuana. At that age, 97.6% of those who were still using cocaine were drinking alcohol, 66.7% were smoking, and 85.6% reported having used marijuana within the last year. By age 34–35 years, the corresponding percentages were 94.6%, 74.0%, and 75.6%, respectively.

To take into account the multiple drug use by cocaine users, we reestimated a second model and included a latent construct of multiple drug use with

cocaine use and health problems from 1984 to 1990 and the long-term positive relation between cocaine use in 1980 and health problems in 1990 suggested that the negative effect on subsequent health functioning was due to the cumulative effect of early onset and multiple years of cocaine use. The selection of specific manifest indicators in the 1984 latent cocaine use construct and, in particular, the inclusion of measures of use prior to 1984 reflected the significant negative path from cocaine in 1980 to health in 1990 in the 3-wave model.

[4] These nonstandard parameters included regression paths from sociodemographic variables to manifest indicators of physical health at age 34–35 years, from cardiovascular symptoms at age 28–29 years to general symptoms at age 34–35 years and age of onset to neurological symptoms at age 34–35 years.



Family income and marital status in 1984 are controlled but not shown. All factor loadings are significant at p <.001. For path coefficients: * p <.05; ** p < .01.

Fig. 2. Causal model of multiple drug use and health problems from age 28–29 years to age 34–35 years (male sample, $n = 532$).

indicators measuring duration and frequency of use of four classes of drugs used since adolescence. Results of the measurement and structural equation models are depicted in Fig. 2. Model fit statistics indicate an adequate fit—$\chi^2(\mathrm{df} = 139,\ n = 532) = 180.0,\ P = 0.01$; $\chi^2/\mathrm{df} = 1.29$, $\mathrm{CFI} = 0.99$. Consistent with Model 1, nonstandard paths were estimated, as suggested by the Lagrange modification indices[5]. Although the P-value is significant, the model provides a good fit to the data as reflected in the ratio of χ^2/df and the CFI. Multiple drug use in the thirteen-year period since adolescence was largely reflected by the use of the two illicit drugs (marijuana and cocaine) and to a lesser degree by frequency of alcohol and cigarette consumption. In addition to the significant effect of multiple drug use on increasing health problems at age 34–35 years ($\beta = 0.12$, $P < 0.05$), cumulative duration of cocaine use had a specific and statistically significant effect on later health problems ($\beta = 0.10$, $P < 0.05$). Duration of frequent tobacco smoking also had a highly significant adverse effect on health problems ($\beta = 0.13$, $P < 0.01$), over and beyond that of being a drug user and specific use of cocaine. The adverse effects of cigarette smoking on the aspects of health that we measured appear to be similar in magnitude to those of cocaine. (The difference between the two coefficients is not statistically significant.)

3.5. Descriptive patterns of chronic cocaine use and health

To elucidate descriptively the differences in health status characterizing different levels and patterns of cocaine use, males were distinguished on the basis of the frequency and chronicity of their cocaine use. These analyses capture a more subtle picture of how intensity

[5] Significant nonstandard parameters included those described in Footnote 3, except for age of cocaine onset, which was not included as a manifest indicator of multiple drug use. In addition, cocaine use at age 28–29 years predicted cigarette smoking at age 34–35 years, cigarette smoking at age 28–29 years predicted alcohol drinking at age 34–35 years, self-reported health problems predicted cigarette smoking, and general symptoms predicted more health problems (latent construct).

Table 3
Selected mean health indicators by cocaine use status at age 28–29 years (1984), ANCOVA with control for demographic variables[a]

	Cocaine Use Status[b] by Age 28–29 (1984)					
	Never used	Light use	Limited heavy use	Chronic heavy use	Overall	Group difference
Health indicators	(a)	(b)	(c)	(d)	*F*-test	SNK Test[c]
Age 28–29 years (1984)						
Mean cardiovascular symptoms	0.33	0.32	0.25	0.47	1.90*	
Mean neurological symptoms	0.40	0.29	0.38	0.58	3.40**	da, db
Mean general somatic symptoms	0.43	0.35	0.42	0.58	3.24**	da, db
Total count of physical symptoms[d]	1.40	0.90	1.31	2.14	2.69**	ab, db
Number of sick/hospital days last year[e]	3.36	2.16	3.07	5.08	1.14	
Age 34–35 years (1990)						
Mean cardiovascular symptoms	0.34	0.37	0.34	0.62	2.23*	da, db
Mean neurological symptoms	0.40	0.33	0.30	0.65	3.71**	da, db, dc
Mean general somatic symptoms	0.45	0.41	0.44	0.69	3.45**	da, db, dc
Total count of physical symptoms[d]	1.52	1.31	1.13	2.65	2.93**	da, db, dc
Number of sick/hospital days last year[e]	2.81	2.74	0.79	7.16	4.56***	da, db, dc
n	393	89	29	21		

Weighted male sample, $n = 532$
* $P<0.10$; ** $P<0.05$; *** $P<0.01$.
[a] Covariates include marital status at 1984, years of schooling, and family income in 1984.
[b] Never-used, never used or used cocaine fewer than ten times; light use, users whose highest frequency ever was two to three times a month or less; limited heavy user, users who ever used once a week or more and for 12 months or less; chronic heavy user, users who used once a week or more for 13 months or longer.
[c] Student-Newman-Kuel test in ANOVA, without control for covariates, indicates the groups significantly different from each other at $P<0.05$.
[d] Count of total number of moderate or more serious symptoms.
[e] Actual number of days. Statistical tests are based on logarithm transformation, which normalizes the distribution of the variable.

of cocaine use relates to health problems and complements the longitudinal path models, which examined changes in distributional variability over time. Males were classified into four groups. A four-level measure indexing non-use, light, limited heavy, and chronic heavy cocaine use by age 28–29 years was created from a set of hierarchical inclusion criteria that captured highest frequency of use and total months used once a week or more from adolescence (1971) through the late twenties (1984). Non-use included those who never used cocaine or used it less than ten times; light users used approximately 2–3 times a month; limited heavy users had used cocaine at least once a week for a total of 12 months or less at that frequency; and chronic heavy users had used cocaine at least once a week for 13 months or longer. The same three sociodemographic characteristics were statistically controlled as in the structural equation models. Table 3 shows selected health indicators at ages 28–29 years and 34–35 years for each category of use. Because the cell sizes are very small, the results should be interpreted as suggestive more than definitive.

At age 28–29 years (1984), chronic heavy cocaine users differed significantly from non-users on neurological and somatic symptoms and from light users on general somatic and total number of physical symptoms, controlling for sociodemographic factors. At age 34–35 years (1990), chronic heavy users differed significantly from all other groups on all health indicators. They reported a greater overall number of health symptoms, a greater number of severe neurological and somatic symptoms, and more sick or hospital days. At both time periods, the mean differences were smallest for cardiovascular symptoms. As the cohort aged, with the exception of number of sick days, the various facets of health adversely affected by cocaine use were the same. However, in the mid-thirties, chronic heavy users reported significantly poorer health than any other group, including the limited heavy users, and reported many more sick or hospital days. Although the differences are not statistically significant, the health of chronic users worsened while that of non-users and of limited heavy users improved slightly over time.

These analyses of variance further support our conclusion that chronic heavy cocaine users experienced

increased physical health problems between the late twenties and the mid-thirties.

4. Discussion

Prospective epidemiological studies represent one of the few strategies available for assessing the negative consequences of long-term substance use in the population. Despite the evidence from medical and treatment samples that cocaine intoxication is associated with health problems, these observations have not been confirmed on general population samples, especially with longitudinal data.

In this study, we used longitudinal data from a general population sample to examine the effects of cocaine use on the exacerbation of physical health problems. The unique data set that was analyzed and the methods used to identify causal relations are strengths of the current study. Whereas previous studies have utilized a static measure of cocaine use (capturing use at one time or lifetime), we used several measures that captured frequency of current and past use, and chronicity of use. Despite our intention to examine these processes separately for males and females, it was not possible to do so. The rates, levels and persistence of cocaine use among females were substantially lower than among males. There were too few heavy female cocaine users to sustain a systematic analysis of the correlates and predictors of cocaine use. On average, correlations between measures of cocaine consumption and physical health for the female sample were small and nonsignificant. These findings are consonant with a recent report from laboratory-based assessment of cocaine users' responses to cocaine. Women were found to be much less sensitive than men both to positive and negative effects of the drug (Lukas et al., 1994). The authors speculate that these gender differences may result from differences in the rate at which cocaine is metabolized and to greater physical barriers that attenuate the absorption of cocaine by females at certain phases of the menstrual cycle.

For males, however, several findings support the conclusion that long-term cocaine use leads to negative health consequences. The magnitude of cross-sectional zero-order correlations between heath symptoms and cocaine use increased at each period of measurement from the mid-twenties to the mid-thirties. The longitudinal model indicated that early and cumulative cocaine use from adolescence to the late twenties predicted increased adverse consequences on health problems when the majority of the sample was between 34 and 35 years old, controlling for current cocaine use, past and current use of cigarettes, alcohol and marijuana, and sociodemographic factors. The persistence of adverse effect of cumulative cocaine use by the late twenties on health by the mid-thirties, controlling for current cocaine use, supports our hypothesis of a time-lagged effect of cocaine.

Data from treatment (Gorelick, 1990; Miller et al., 1990; SAMHSA, 1996b) and general population samples (Newcomb and Bentler, 1987a, 1988; Kandel and Davis, 1991; SAMHSA, 1995b) suggest that cocaine users are highly unlikely to restrict their drug use to a single substance. To avoid making incorrect causal attributions, we tested a model which, in addition to cocaine use, specified length of frequent drinking, smoking and marijuana use in the period between adolescence and the late twenties. Even when we included measures of other licit and illicit drug use, cocaine use still maintained its predictive prominence and had a negative influence on health. Further support for the hypothesis of a delayed and chronic effect was provided by the results of the analysis of variance, which showed that chronic heavy use by the late twenties, as opposed to sporadic or experimental use, was associated with a greater number of health problems in all the areas of health functioning that we measured.

Cigarette smoking had a unique significant negative effect on health problems over and beyond the effects of overall drug use and specific cocaine use. The negative health consequences of smoking have been well documented (Kasuga et al., 1991; US Department of Health and Human Services, 1989). The present research suggests that cocaine use has adverse effect on health problems similar to those of cigarettes in terms of the direction and magnitude of effects.

The results also suggest that the relationship between cocaine use and health is recursive. That is, not only does cocaine use lead to a deterioration of health but unhealthy men are more likely to continue to use cocaine, leading to a spiral of increasingly poorer health. The influence of physical health status on illicit drug use has not generally been discussed, except by Castro et al. (1988), in contrast to the relationship between psychological symptoms and the use of drugs as self-medication. The positive relationship between poor health and cocaine use may reflect common lifestyle factors that characterize certain groups in the population, but that were not controlled for in the present study.

4.1. Underlying mechanisms

What are some of the potential health-related activities that foster the delayed effect of cocaine on physical health? One hypothesis is that the better health of young adults in their twenties may have protected the heavier cocaine users from the deleterious effects of cocaine in its earliest stages of use compared with the cumulative effects at an older age. Consumption of cocaine during the twenties may not continuously exert

a negative influence on health problems, but at some point along the time continuum a pathophysiological threshold may be reached that activates symptoms in sufficient quantity for detection. Although cocaine use at earlier time periods did not reveal significant adverse consequences on physical health problems, the longer term cumulative patterns of cocaine use over a six-year interval accounted for positive co-variation with such problems. Chronic users characterized by early onset, greater number of years used, and more frequent use were more likely to report physical health problems than more recent and sporadic users. Because the negative effects of cocaine use are pronounced with acute and repeated intoxication (i.e. runny nose, agitation, fluctuating body temperature), once these acute symptoms subside, longer term more pervasive damage may go undetected. Cardiologic functioning, in particular, may be sensitive to the suggested delayed or lagged effects. Once a cocaine-induced arrhythmia subsides and blood pressure returns to normal, there may be limited opportunity for self-detection of more severe long-term cardiologic damage (e.g., cardiomyopathy). The findings underscore the need for greater precision with regard to specifying the point of developmental inflection and the threshold for activation of a risk factor.

4.2. Limitations

Several limitations to this study must be noted. As is true of general population samples, the proportion of heavy cocaine users is low. As a result, the sample sizes in certain cells are small and may contribute to low power in the detection of significant differences. The longitudinal analysis limited to males cannot be generalized to female cocaine users without further cross-validation. In addition the male model did not include other potentially relevant factors. Many important lifestyle variables, such as diet, exercise, sleeping habits, and other determinants of overall health functioning, were not measured. The conclusions need to be further verified with appropriate controls for other potential intervening factors. It would be crucial to replicate the analyses in larger samples of males and females.

Additionally, self-reported measures of drug use and physical health were used. Evidence is accumulating that while self-reported drug use is quite accurate (Needle et al., 1989), there is underreporting under certain conditions (Turner et al., 1992). Multiple methods and corollary information could increase internal and external validity (Stacy et al., 1985). Moreover, with regard to health problems, the use of independent physical histories and medical data would both enhance internal validity and provide a more accurate means of measuring the severity of health problems. Finally, and somewhat related to the latter point, neither the drug use nor the physical health measures were based on diagnostic criteria. We were unable to classify individuals on the basis of a substance use disorder or categorize their physical illnesses using clear medical diagnostic criteria. The categories of medical and health problems that we used were in keeping with previous medical tradition and empirical evidence based on studies of symptom checklists. The lack of specific diagnostic criteria, however, does not exclude extreme forms of both cocaine use and physical health problems from the sample, which was drawn from the general community.

The most noteworthy finding of this study is the contrast between the lack of contemporaneous effects from cocaine use on physical health in the late twenties and the delayed adverse effects by the middle thirties resulting from chronic use observed in the sample of men that we studied.

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