

**THE THREE MILE ISLAND INCIDENT:
A STUDY OF BEHAVIORAL INDICATORS
OF HUMAN STRESS***

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This work sought to specify stress levels induced in the local population around Three Mile Island from the accident in 1979. Unobtrusive behavioral indicators of stress for the population as a whole were compared before, during and after the accident. The conclusions reached were that: (1) the Three Mile Island incident did produce stress in people, (2) the stresses detected through the indicators used in this study were short-lived, not severe enough to manifest themselves in dramatic indicators like psychiatric admissions or suicide, (3) stress was obviously reflected in indicators of mild stress like alcohol consumption, and (4) stress detected was well within the limits of stress that occur annually in that local population from stress inducing events like the occurrence of a major holiday. The conclusions of this study are best interpreted in concert with findings from studies using obtrusive indicators of stress, and with studies on special local sub-populations.

* This is a revised version of a paper presented at the Annual Meetings of the Midwest Sociological Society, Session on Hazards and Disasters, Kansas City, April, 1983. Funding for this study was provided by General Public Utilities, Metropolitan Edison, owners and operators of the nuclear generating reactors on Three Mile Island (through Shaw, Pittman, Potts and Trowbridge,

The Spring of 1979 beheld tens-of-thousands of people evacuating their homes for an unprecedented reason: a malfunctioning nuclear reactor on Three Mile Island (TMI) was thought by some to be a threat to human health and safety. It has been estimated that some 144,000 people evacuated the greater Harrisburg-Middletown, Pennsylvania area and beyond (cf. Flynn, 1979; Flynn and Chalmers, 1980); many others who stayed behind expressed fear.

The incident at TMI has been examined in detail by scientists of all sorts. Investigations have been intense and some still continue. The aim of most of these efforts was to determine what happened to people as they sought to cope with the news that a familiar landmark could be turning into a foe. The inventory of studies which has been compiled is impressive (cf., for example, Barnes and Mitchell, 1979; Bromet, 1980; Brunn et al., 1979; Chenault et al., 1980; Dohrenwend et al., 1979; Flynn, 1979; Flynn and Chalmers, 1980; Goldstein, 1979; Governor's Office of Policy and Planning, 1979; Houts, 1980; Kraybill, 1979; Kraybill et al., 1979; Mitchell et al., 1979; President's Commission on the Accident at Three Mile Island, 1979; Schearer, 1980; Staff of the Nuclear Regulatory Commission, 1980; Technical Staff to the President's Commission, 1979) and continues to grow. A good many of these efforts have sought to explore the nature and character of the stress which the incident induced in the human population.

It is the purpose of this study to attempt to describe this same TMI incident-induced stress factor in the human population. However, unlike most other studies which sought to measure stress through the questionnaire or interview methods, this study used an alternative means of measuring the possible stressful effects of TMI--the indirect measurement of stress through unobstrusive measures. It seemed desirable to use this alternative measure of stress because the psychological study of stress through question-answer research designs is not a well-developed science. Mason (1975) reflected much the same

Washington, D.C.) which is gratefully acknowledged. However, only the authors are responsible for the contents and conclusions of this paper. The authors also wish to express their gratitude to Victor Fongemie and Janet Kelly of the Division of Mental Health for the Commonwealth of Pennsylvania for the support they provided in the collection of data; as well as all others in state agencies and departments who assisted us. The Department of Health for the Commonwealth of Pennsylvania, before the research was begun, disclaimed any association with the results of this work.

sentiment in an overview of the psychology of stress:

In the psychological stress field, it has been observed repeatedly that responses to any given psychosocial stimulus may vary widely from one individual to another, or from one time to another in the same individual. It has been found further that such responses become increasingly predictable only when other intervening factors, such as the previous experiential history, the coping or defensive style, or the idiosyncratic factors in threat perception, are taken into consideration for each individual subject. As a result of this recognition of the complexity of the interacting factors which determine behavioral and physiological responses to psychosocial stimuli, there has been a natural tendency to view psychological stress phenomena in a broad, many-sided perspective and to avoid simplistic, unilateral definitions based either on input or output parameters alone (p. 11).

Stress cannot be measured directly because it is not a tangible phenomenon. Only the effects of stress--muscle fatigue, tension headaches, increased grouchiness, or decreased control over behavior and emotions--are observable and can be measured. Another misconception about stress is that it is one thing rather than a conglomerate of many. This impression is given and reinforced by headlines such as "REACTOR ACCIDENT CAUSES STRESS IN TMI POPULATION." Such notions are hard to dispel and can lead to misunderstanding because some indicators of "stress" may go up while others show no effects.

Unobstrusive measures are comparable to economic indicators used for measuring the health of an economy or archival data used for a variety of social research studies; however, scholars have not developed a standard set of unobstrusive measures of stress comparable to economic indicators. Instead, different unobstrusive measures are used, depending upon the specific research needs. Additionally, many researchers have used unobstrusive measures without developing a rationale or justification for their use. This is likely unwise; there are complications and limitations with the use of these measures just as there are with any others.

Definitions and measures of stress have differed across most TMI studies. Some researchers used gross indicators where, for example, evacuation was equated to stress (cf. Flynn, 1979). Yet others simply asked people to estimate how much stress they experienced (cf. President's Commission on the Accident at Three Mile Island, 1979). Some used developed indices in the form of a battery of interview questions (cf. Houts, 1980). Most, if not all, however, relied on verbal accounts by residents

to develop stress estimates. Such a technique is useful, as many have claimed, because if someone is willing to admit to stress, it could mean that it actually did exist. Nevertheless, a critical piece of the stress research puzzle about TMI is missing. This is the cataloging of different kinds of observable behavior that could be taken as the consequences of stress. For example, changes in the consumption of alcohol, auto accidents, crime, and other observable behaviors that could indicate altered patterns of stress in the population.

The advantages of such an approach to the study of stress are clear. First, data on these behaviors are routinely collected, and enable comparisons of before, during, and after estimates. Second, these measures are unobtrusive; they can be gathered without the population knowing that it is being observed, which can sometimes alter the soundness of measurements. Third, results from a study using an unobtrusive indicators approach is not contaminated by biases resulting from how people answer questions about their feelings or behavior. The approach, however, has its own shortcomings. For example, archival data varies in its accuracy. Suicide rates, for example, are subject to the decisions made by individual coroners. In many instances, deaths by suicide are listed as accidental deaths for political reasons or out of respect to the grieving families. There is also a normal fluctuation in archival data, such as the number of automobile accidents or the suicide rate, from one year to the next. Archival data also normally return toward the mean, especially after wide fluctuations. In other words, if for some reason the accident-induced stress rate was twice this year what it was for the last five years, we would be safe in predicting (other things being equal) that next year it would tend to return toward the mean rate of the last few years.

Given the inherent advantages and disadvantages of a study of stress using an unobtrusive indicators approach, this research sought to fill a gap in the work on human stress from the Three Mile Island incident. The study is not definitive; rather, it is intended to add one more tile to the mosaic of studies addressing the topic. It does, however, have a key advantage not offered by other approaches. Within the limits of how thoroughly data are collected by the various state agencies and departments who maintain such counts, measures of behavioral manifestations of stress are fact and not subject to how study respondents interpret, remember, or perceive facts. Given the profound significance that the Three Mile Island incident has and will likely continue to have on the national scene, decision makers should be provided the most complete information the behavioral sciences can offer.

Stress and Health

The notion that there is a relationship between what happens to people and their health has existed for a long time. Tuke (1872), for example, suggested that dramatic life events produce health effects. Later, psychoanalysts such as Freud and Adler related stress to illness susceptibility. Physiologists Cannon and Selve experimented with physiological effects of emotional stress in animals. Researchers and clinicians on the human effects of stress included Alexander, Meyer, Cobb, and others (Rahe and Arthur, 1978). Current research by Rahe (1978) has suggested that life events dictate changes, and that these changes require personal adjustment by the individual experiencing them. He assumes that more stress requires greater degrees of adjustment. Stress produces physiological changes (some of them are documented while others are assumed) and these physiological changes can result in greater susceptibility to illness. Thus, there is an established chain of cause and effect between stressful life events and illness.

Rahe and his colleagues maintain that all life changes are stressful, even desirable ones such as promotions and Christmas. Subsequent research has shown, however, that undesirable events are more influential by far in producing illness and psychiatric symptoms (Roso and Mirowsky, 1979). Another factor influential in producing illness and psychiatric symptoms from stress is locus of control. For example, people would have little control over events such as death of a spouse, tornadoes, and the like, but might have considerable control over divorce, marital separation, or voluntary surgery. The assumption is that events with the possibility of control produce less stress than those without control.

Regardless of the model or theory being used, scholars do agree that there are intermediate steps between the occurrence of an event and the development of some kind of stress-related behavior such as an illness. These variables include psychologically oriented ones, such as the adequacy of a person's coping defenses; social variables, such as the presence or absence of a support group for the person who has experienced the event; and physiological variables, such as the quality of the individual's body chemistry. The presence of all these different variables means that prediction of resultant behavior is somewhat imprecise.

TMI Stress Indicators and Hypotheses

Unobtrusive stress measures have been the subject of research

by other investigators. Although this research area is less than well-developed, some work exists on which the hypotheses for this study were built.

Cardiovascular Deaths

There is a causal link between the occurrence of a higher number of life events and myocardial infarction. For example, Rahe and Romo (1974:109173) have illustrated that stress levels correlate with seasonal activities, and that stress levels increase just prior to heart attack. As well, Theorell and Rahe (1975:18) have documented that life changes and their correlated stress indicated a significant build-up prior to death from coronary disease in another study. Finally, Connolly (1976) illustrated that significant and stressful life events increased three to twelve weeks before myocardial infarctions in his group, and peaked just three weeks before heart attack. Despite this and other research evidence, the relationship between stressful life events and coronary disease is far from precise. It can, nevertheless, be concluded that a significant increase in heart attack frequency in the TMI population, beginning about three weeks after the accident, could be taken as an indicator of accident-induced stress. The hypothesis for this research was stated as follows. If stress existed as a result of the TMI incident, the TMI population will demonstrate a significantly increased number of cardiovascular deaths for six months following the accident, as compared to the control group who did not live in the area.

Psychiatric Admissions

It can be argued that if a population experiences high levels of stress for a protracted period, one manifestation of that stress would be the increased utilization of mental health care facilities. However, it is important to keep in mind that only a fraction of those experiencing such stress would be expected to go on to develop psychiatric illness (cf. Rahe, 1979:2). These conclusions rest on, for example, the work of Paykel (1964) who found that depressed patients experience about three times as many stressful life events before depression than others; the research of Jacobs, Prusoff and Paykel (1974) who reached the same general conclusion as Paykel in reference to psychiatric inpatients; the theorizing of Rahe (1979); and a study of schizophrenia by Brown and Birley (1968). However, the influence of stress deriving from the TMI accident would likely influence psychiatric admissions through indirect means, rather than direct ones as was the case with myocardial infarction. It is fairly well documented that emergencies alone do not produce

an increase in severe mental illness. For example, Taylor (1976) described two new programs that were designed for an expected influx of psychiatric admissions after the Zenia tornado in 1974. Referring to one plan, she states, "this plan, however, collapsed as a result of an almost non-existent demand for the services" (p. 147). "Furthermore, at the county hospital, the point of final referral for the Three Stage Plan, psychiatrists reported seeing only about a dozen persons, (and) most of these problems were longstanding and unrelated to the tornado. In fact, the majority of these persons were not even direct victims of the tornado" (p. 274). Thus, psychiatric admissions after the TMI accident would most likely go up because of various changes in the lives of residents, rather than because residents became emotionally disturbed as a direct result of the accident. The hypothesis for this research follows. If stress existed because of the TMI incident, psychiatric admissions for the TMI population would show a significant increase over the six months following the accident as compared to the control population.

Suicide

It has long been recognized that suicide rates vary with a number of demographic, economic and sociological factors (Henry and Short, 1954). More recently in a large and somewhat definitive work, Maris (1981) has demonstrated that suicide attempters are a different but overlapping population from those who successfully kill themselves. The conclusion of this work was that the suicide attempter is more prone to be responding to current life deficits than the individual who completes a suicide whose suicide antecedents may be rooted in early life and subsequent development. It is suicide attempters, therefore, who are a highly vulnerable group with regard to recent life events (Paykel, 1976 and 1974). This suggests that stress stemming from an emergency would more likely be reflected in attempted rather than completed suicides. This is particularly the case because it has been found that a marked peak in stress existed in the month prior to attempted suicides (Paykel, 1976:8). It would appear, therefore, that suicide attempts would be a more sensitive stress indicator for the TMI population than completed suicides.

Automobile Accidents

Although automobile accident rates are influenced by many factors--for example, road conditions, mechanical problems, weather and so forth--human factors have been estimated to account for some 90 percent of all accidents (McFarland and Moore, 1957). Some suspect that accidents could be suicide

attempts (Farberow, 1980); others (Selzer, 1980) discount the notion. Finch and Smith (1970:20) provide the most straightforward account of how stress could relate to accident rates. They concede that stressful events interact with an individual's character structure and personality type. The result could be to either increase or decrease the potential for an automobile accident. Finch and Smith, in a small study of 25 auto accident fatalities found that 80 percent of the drivers in fatal crashes had experienced significant stress in the 24 hours just before the crash. The TMI hypothesis for auto accidents follows. If the TMI incident produced stress, the number of automobile accidents, especially those involving single automobiles, will be significantly higher for the population around TMI during the six months after the accident than for the control population.

Alcohol Sales

In the popular media, there is an obvious link between personal stress and alcoholic consumption. In alcohol research, the analogous hypothesis about alcohol consumption is called the tension-reduction hypothesis. The notion is that people drink, in part, as a response to stresses and strains in the environment because of alcohol's presumed tension-reducing properties. This is, indeed, a conclusion borne out by actual research. For example, Higgins and Marlatt (1975:649) conclude that alcohol consumption increases in "... situations that the drinker defines as being stressful and in which it is believed that alcohol will reduce the stress or tension." As well, Stickler, Tomasyewski, Maxwell and Suib (1979), in a controlled experiment, illustrated that alcohol consumption increases with stress. The consumption of alcohol, however, is a somewhat different unobstrusive indicator of stress than the others included in this study. It is actually one means of coping with stress, rather than an effect of stress. The hypothesis for this research was that if the TMI accident produced stress, the sale of alcoholic beverages would show a significant increase in the six months following the accident in the local population, whereas no such increase will exist in the control population.

Crime

Some theorists promote single-sided explanations for criminality, for example Eysenck (1977); although most espouse a person-environment interactionist point of view. Little actual information exists which relates crime to stressful life events (Lillyquist, 1980). One notable exception was Taylor's (1976) study of the Xenia tornado and stress. Significant increases

were found in juvenile delinquency, traffic violations, unruliness, delinquency and neglect, and criminal traffic cases. Other crimes should not increase, while others actually declined. Taylor concluded (1976:271) that these mixed findings suggested that there were no real increases in the number of cases entering the criminal justice system, but rather there was a rise in the number of cases actually processed. The hypothesis for this research was that if the TMI incident produced stress, that there would be an increase in the number of criminal arrests in the TMI population for the six month period following the accident, while no such increase would exist in the control population.

Research Design

The design used in this research was selected in order to enable behavioral indicators of stress to be compared across time (before, during and after the incident), and between different populations defined by geographical proximity to the TMI reactor (very close, somewhat close, and far enough away to constitute a control group). Data for each indicator examined were, therefore, catalogued in terms of time and geography in order to approximate an ex-post-facto field experimental design.

Geographical Study Areas

Three different populations were selected for study. The first was comprised of all boroughs and townships that conformed as closely as possible to a five mile radius around Three Mile Island. The second was the five-to-ten mile band that surrounded the inner radius; it included all boroughs and townships that fell roughly within this area. These populations were distinguished because evidence from other studies had suggested that stress could be geographically dispersed in an outward fashion from the plant. Actual borough and township boundaries were used instead of concentric rings because data were not available below this level of aggregation for most of the behavioral stress indicators. A third population was included as a control group. It was matched as closely as possible to the composite of both experimental groups on selected demographic characteristics. In order to maintain some comparability between this and other studies, the control group was selected from the general Wilkes-Barre area. It consisted of 30 contiguous boroughs and townships, in proximity to but excluding the urban area of Wilkes-Barre.

Time Frame and Standardization

This study used data that were routinely collected by agencies

and departments of the Commonwealth of Pennsylvania. At the time the study was begun, data were available only through the third quarter of 1979. This influenced how study before and after time intervals could be defined. Data on stress indicators were only available for six months after the TMI incident. Data were collected from October 1, 1978, through September 30, 1979. The pre-incident time interval was six months long and ran from October 1, 1978 to March 27, 1979; the post-incident six-month interval ran from March 28, 1979, through September 30th. Except for manifestations of stress that could take longer than six months to surface, the one-year span for which data was collected allowed seasonal variations in indicators to be eliminated when experimental and control group comparisons were made. Data were aggregated on a monthly basis for the study year, and on a daily basis for March and April so that fluctuations in indicators could be inspected in more detail, where appropriate, for the four weeks before and after the incident. Daily incidence data were standardized, where appropriate, during the days over which evacuation took place to eliminate the potential bias of fluctuations in population size. As well, data were standardized so that the potential bias of months with different numbers of days affecting incidence rates would be eliminated. In addition, data for monthly incidence rates were adjusted so that March could be interpreted as a "pre-accident" month while April could be seen as the "month of the accident."

Definition of Indicators

The data compiled on unobstrusive stress indicators were defined on the basis of how they were maintained by state agencies. When there was more than one way of maintaining the data, all ways were used in the study.

Alcohol sales were defined as the sale of liquor, beer and wine at state liquor stores. Data were divided into: 1) retail sales as non-case sales to individuals; 2) tavern sales as sales to licensed taverns; and 3) total sales as retail and tavern sales plus case sales to individuals. Data for each were recorded as the dollar amount of sales. Dollars does not necessarily covary with volume, since dollar sales would not reflect changes in the sale of expensive versus inexpensive liquor if such a shift occurred. Dollars also need not covary with the amount of alcohol consumed. Despite these disadvantages, it did seem reasonable that alcohol sales would vary enough with actual consumption to warrant investigation. Monthly sales figures for liquor sales were actually 28-day periods. The percentage of sales made with each 28-day period of the study year is presented. It is

important to keep in mind that alcohol sales routinely increase at certain points in time, for example, at holidays and on weekends.

Cardiovascular deaths data were examined according to the International Classification of Disease in its eighth and ninth revisions. Three classifications were examined: 1) acute myocardial infarction; 2) ischemic heart disease; and 3) other forms of heart disease. These data were not adjusted for changes in population size since data were maintained on the basis of residence rather than place of occurrence. The study time period included a change in the reporting system. For this reason the full study year was appraised only for acute myocardial infarction; data for the nine months of 1979 within the study year were reviewed for other indicators. For monthly totals, the data are presented as the percentage of incidents occurring within a standardized month of the entire study period. Standardized incidence occurrences were also examined since percentages for low-incidence events such as cardiovascular deaths could be misleading.

Reported crimes were examined as classified in the Pennsylvania Uniform Crime Reporting System. Two classifications were examined: 1) serious crime including criminal homicide, forcible rape, robbery, assault, burglary, larceny-theft and vehicle theft; and 2) minor crime including all minor crimes, for example, minor assault, arson, fraud, stolen property, prostitution and commercialized vice, drug use violations, offenses against family and children, driving under the influence, and drunkenness. Finally, two individual crimes were singled out for special examination--burglaries and drunkenness. Data were obtained only on a monthly basis; daily data were not available.

A psychiatric admission, as defined for the purposes of this study, occurred when a patient completed the forms necessary to gain initial intake status at a County Mental Health or Mental Retardation Center. Psychiatric admission data were not available for the municipalities and townships used for other study indicators and were not available on a daily basis. These data were maintained by catchment areas which were arranged for this study in a way that would approximate study areas for other indicators as closely as possible. It should be kept in mind that persons living in one catchment area could present themselves to a center in another catchment area.

Suicide was taken as deaths by suicide, deaths by injuries in suicide, attempted suicide and self-inflicted injuries specified as intentional according to the International Classification of Disease. These data did not require standardization for

evacuation because incidences were coded by address of residence and not place of occurrence. Very few suicides occurred during the study year so these data should be reviewed with caution. Typical seasonal variations in suicide should also be kept in mind.

Data for automobile accidents were divided into four categories: 1) fatal accidents were those in which at least one fatality was experienced; 2) injury accidents were those that resulted in bodily injury but not death; 3) property damage accidents were those in which property damage resulted, but not injuries or fatalities; and 4) total accidents included all three of the above sub-categories. The data were standardized for the evacuation of population. This could, in and of itself, increase incidence rates for an evacuating-returning population if evacuation increased the number of vehicles on the road. It could be argued that it would have been appropriate to adjust these data to control for changes in traffic during the incident; however, it was impossible to find a basis on which to build reasonable multipliers. These data were adjusted for evacuation in order that our procedures be the most conservative; that is, err on the side of finding stress in the population.

Data Analysis Technique

Statistical techniques fall into two general categories: parametric inferential statistics. The latter tests were not used in the analysis of study data because population data and not sample data were used in this study. That is, because the study used population data, and observed differences in data were actual differences, statistical significance was not relevant to interpretations of these differences.

Data and Findings

Sales of Alcoholic Beverages

The TMI incident was probable cause of changes in the volume of alcohol sales and, likely, consumption for the first three days after it began. All three indicators of alcohol sales--total sales, tavern sales and retail sales--revealed the same pattern. Alcohol sales began a small rise on the day the incident began, reached their peak two days later, and returned to typical levels the next day (see Figures 1, 2 and 3). They did so across the three study populations in the way that would be expected if the incident induced stress in the public experiencing it. All indicators revealed larger increases in the population closest to the reactor (the 0-5 mile radius), lesser increases in the population further

from the reactor (the 5-10 mile ring), and no apparent change from normal trends in the sale of alcohol in the control population. Two points should be made about these data. First, they were adjusted for evacuation and, if evacuees were comprised of people who tend to drink less than the general population, then these findings would over-represent differences

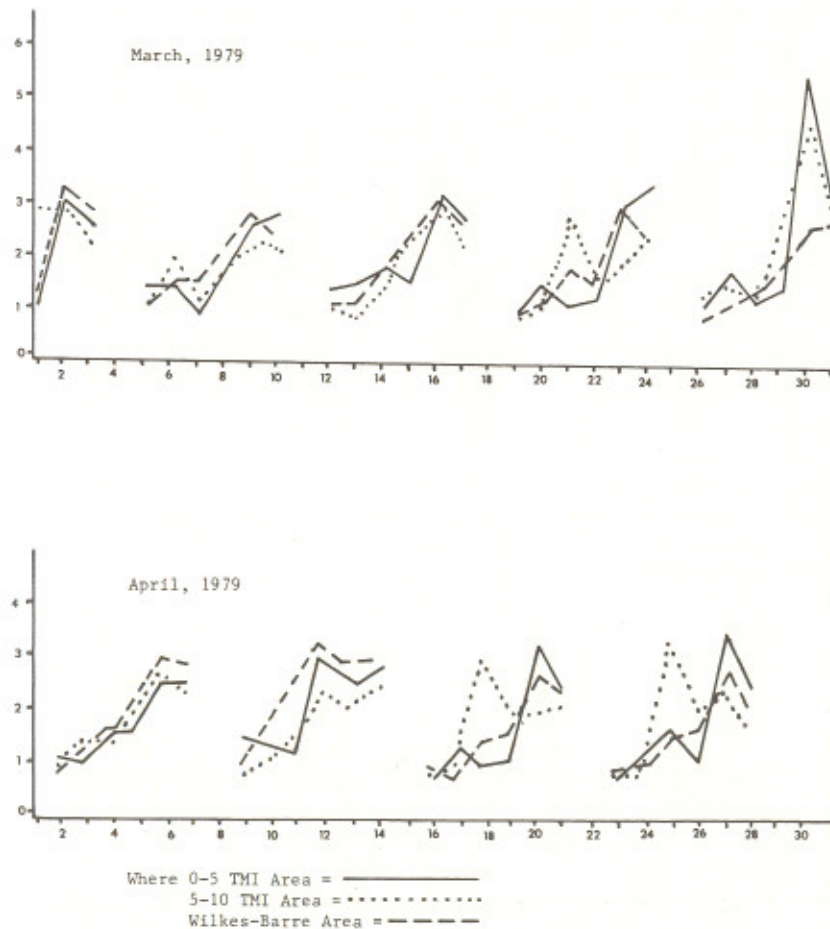


Figure 1: Total Alcohol Sales by Day for March and April of 1979 Adjusted for Evacuation.

between the populations studied. Second, the observed differences were short-lived and, even at their highest point, alcohol sales did not increase beyond levels characteristic of consumption patterns during the Christmas holidays, the highest consumption period of the year. It is, however, reasonable to conclude that

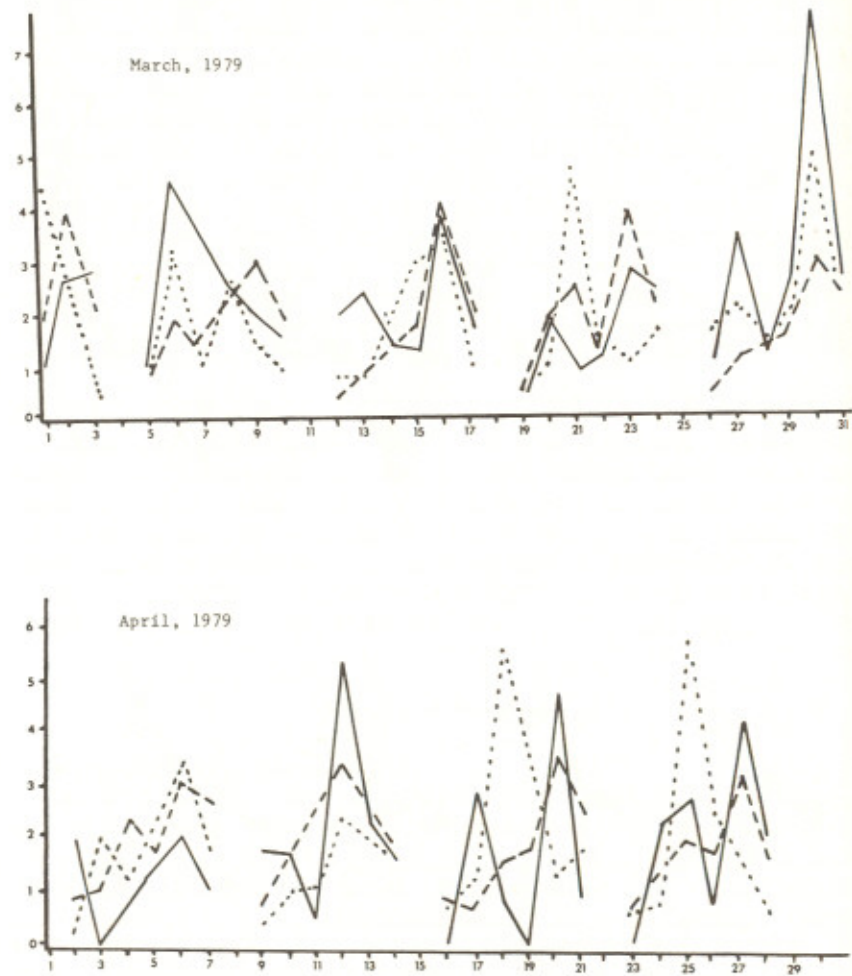


Figure 2: Tavern Alcohol Sales by Day for March and April of 1979 Adjusted for Evacuation.

the TMI incident increased the sale of alcoholic beverages for a short period of time in a way consistent with the conclusion that the incident was stress-inducing.

Cardiovascular Deaths

There is a problem interpreting study data on cardiovascular deaths because the incidence of deaths was so small. The incidence of acute myocardial infarctions was slightly up in

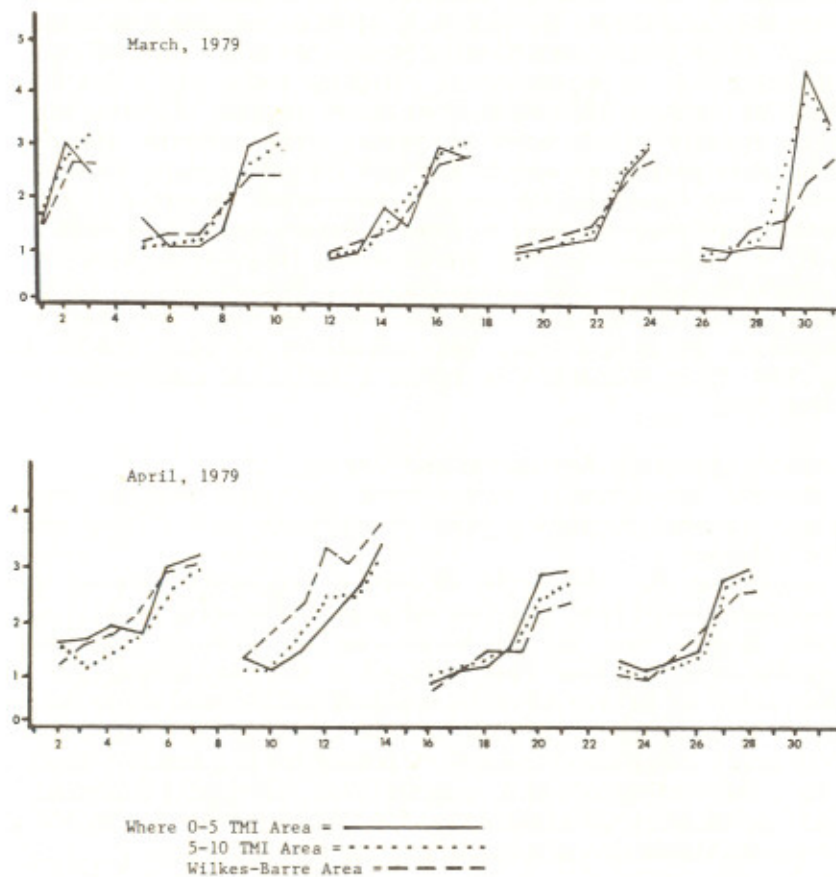


Figure 3: Retail Alcohol Sales by Day for March and April of 1979 Adjusted for Evacuation.

the 0-5 mile ring population in April. There was a total of seven deaths in April; three clustered at the end of the month. An increase was also observed in the 5-10 mile radius population in May and June. No increase were noticed in the control population (see Figure 4). These increases were not dramatic and were not higher than typical seasonal highs at other times of the year. This was also the case for deaths from ischemic heart disease (see Figure 5) which seemed to increase, beginning in April for the 0-5 mile radius population, and in May for the 5-10 mile radius population. Rates dropped dramatically in both populations for ischemic heart disease in July. It should be kept in mind that the incidences of deaths being discussed were very small; that is, what is labelled an increase was actually two or three more cases. Deaths from other heart disease showed no change. It is impossible to attribute these extra deaths to the TMI incident. No evidence exists to suggest that the deaths were directly precipitated by news of the incident. However, these data provide no way to discount the notion that, for several people, the incidence did not add an element of stress to a pre-accident profile sufficient to cause coronary death. One difficulty with this indicator is that the observed frequencies were small enough that they may have occurred because of the periodic fluctuation characteristic of this type of data. Or, they may represent an actual increased probability of such deaths due to TMI. It is impossible to reach a definitive conclusion from these data.

Crime, Psychiatric Admissions and Suicide

Several indicators of crime were examined--serious crimes, minor crimes, burglaries, and drunkenness and driving under the influence.

Inspection for indicators of crime suggested that no real changes resulted from the TMI incident. Differences in incidences were largely not in the directions or patterns that were hypothesized if stress were induced in the population; instead, they seem to be due more to seasonal and/or random variation. One exception might be that serious crime in both the 0-5 and 5-10 study areas (see Figure 6) increased for the summer months. The data assembled also suggest that psychiatric admissions and suicide were not affected by the TMI. However, the incidence of suicide was so low as to make any conclusion difficult.

Traffic Accidents

The variation observed in traffic accident data during the TMI incident were slightly and not clearly indicative of stress. Generally, a few more accidents involving injuries and property

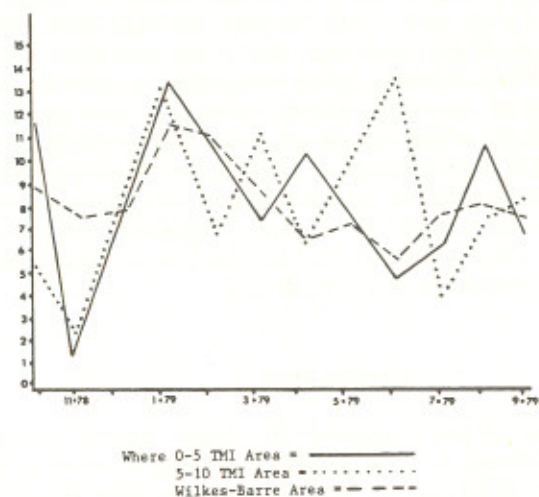


Figure 4: Death from Acute Myocardial Infarction by Month.

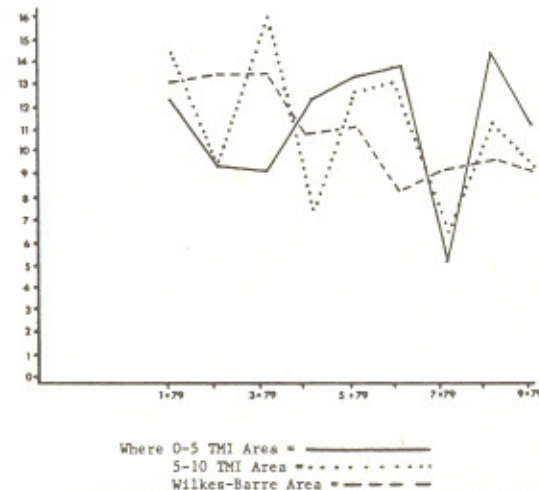


Figure 5: Death from Ischemic Heart Disease by Month.

damage were observed over the period of March 30th through April 4th (see Figures 7 and 8). Most of these occurred on the 3rd and 4th of April, and most of the increase was in the 5-10 mile ring. This slight detected increase could be the result of several possible causes acting individually, or in concert. They include stress and increased vehicular use of highways associated with evacuation and return. It is also possible, however, that the slight observed increases are proportionately well below what can be attributed to stress, especially considering that the incidence of accidents data were adjusted for evacuation in the population. Increases in the incidences of accidents were too low for a clear conclusion to be drawn.

Conclusions

The Three Mile Island incident did cause human stress. The stress revealed through this study of unobtrusive indicators of stress-induced behavior in the population was slight, short-lived, and well within routine levels experienced by the populations studied during seasonal highs in a typical year. This, however, does not mean that stress which did not manifest itself in behavior did not also exist in the population.

Very little can be found in the data examined to demonstrate

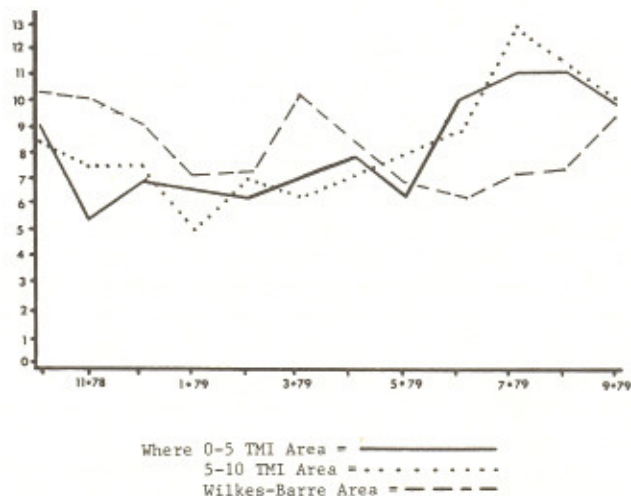


Figure 6: Serious Crime by Month Adjusted for Evacuation.

significant levels of stress as manifested in actual behavior. The incident elicited enough stress in the population to cause behavioral changes in terms of a pronounced increase in the sale of alcohol beverages for the first few days of the incident. Data on crime, psychiatric admissions and suicide did not reflect observable changes that could be taken as indicative of stress. Traffic accident data showed some slight increases in the 5-10 mile ring several days after the incident began. This increase

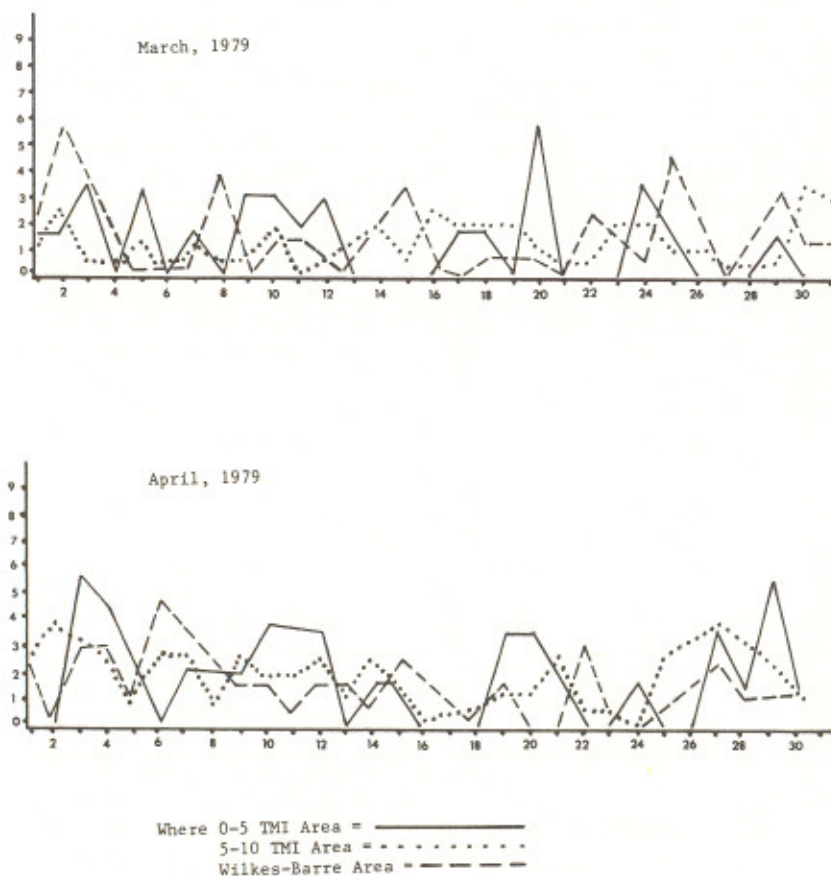


Figure 7: Accidents with Injuries by Day for March and April of 1979 Adjusted for Evacuation.

could be, but is not clearly, indicative of stress. Finally, cardiovascular deaths seemed to increase slightly in the pattern one would expect if stress existed in the population. However, the incidence of cardiovascular deaths was so small as to make the incident-deaths inference very problematic on the basis of these data.

In sum, it can be said that the unobtrusive indicators of stress included in this study suggest that stress as manifested

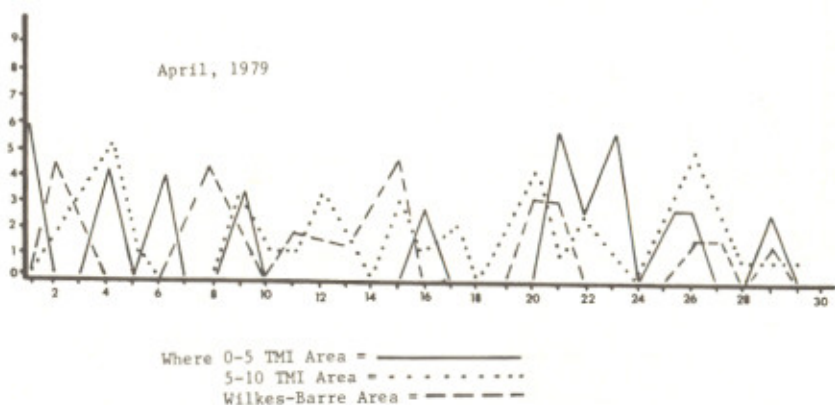
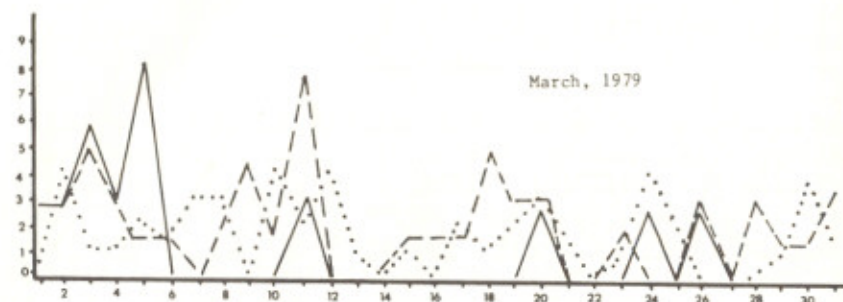


Figure 8: Accidents with Property Damage by Day for March and April of 1979 Adjusted for Evacuation.

in changed human behavior at the population-level was slight, short-lived and not beyond levels typically experienced in a human population during annual events that typically induce stress, for example, the Christmas holidays. This conclusion should not be misinterpreted. Stress did exist in the TMI population; however, it clearly manifested itself behaviorally in the less directly harmful indicator of alcohol consumption, as opposed to more dramatic indicators such as heart attack, psychiatric admissions, and the like. We feel confident that other indicators of less harmful behavioral manifestations of stress--for example, tranquilizer sales, aspirin consumption, and others--would have had similar patterns to those for alcohol.

The conclusions of this study are best viewed and interpreted in the context of other studies of TMI incident-induced stress that have used obtrusive indicators. A good deal of stress could exist in a population before it manifests itself in unobtrusive indicators of behavior like those examined in this work. Other studies which sought to measure less harmful manifestations of stress, such as worries over health and bodily tension, did conclude that it existed. This study's contribution may be in having determined the behavioral upper limit of the stress induced by the incident; it was surprisingly low when it is considered, as we have done, in terms of the population as a whole. This is not to say, however, that it could not have been high for a particular individual or small group of individuals whose stress-response was somewhat masked in this study which considered the population as a whole.

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