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THE APPLICATION OF CAPTURE-RECAPTURE FOR INDIRECT POPULATION ESTIMATION

By

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ABSTRACT

THE APPLICATION OF CAPTURE-RECAPTURE FOR INDIRECT POPULATION ESTIMATION

By

Lori Ann Wibert

Sociologists maintain two tenets when it comes to population estimation - - a census or a sample. Both estimation procedures are limited for counting hidden populations such as domestic violence. Victims are not represented in random surveys because of sampling bias while registries from police departments and shelters are incomplete because most persons never report their crime. This dissertation borrows a methodology from animal population scientists known as capture-recapture which involves tagging individuals and matching them between samples to estimate the invisible population. These findings suggest violence from intimate partners is more pervasive than indicated from national studies and that women are battered more than 17 times the rate of men.

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CHAPTER 1 -- INTRODUCTION

I. Introduction

Social scientists have been investigating intimate partner violence for less than 30 years even though it has always permeated family life. Intimate partner violence as a scholarly focus differed from other topics of social research because concurrent with academic development, activists and professionals were advocating for victim's rights. Some researchers developed within the battered women's movement and some studied it abstractly from the outside. Researchers and advocates originated from different backgrounds and goals that led to opposing points of view (Geffener, 1987; Jacobson, 1994; Schechter, 1988). There has been dissension not only between activists and academics but also between disciplines within academia (Yllo, 1997). From the very beginning, researchers on this social problem were at odds. Fagan (1988) suggested differential theoretical frameworks are rooted in the varying research methodologies, data collection procedures, and definitions. The newness of the field combined with methodological limitations has led to an impasse of why violence occurs, who are the victims, and violence characteristics. Violence is a difficult and elusive topic to study and this has compromised traditional research methodologies. Therefore, theorizing about intimate partner violence is based on the conclusions of limited methodologies.

This dissertation will approach intimate partner violence research with a new statistical technique to erode existing research barriers. The methodological technique, capture-recapture, is adapted from wildlife and animal researchers to characterize the population of violence between intimate partners. This study will demonstrate how the new

statistical procedure will open up the theoretical development of the study of violence perpetrated by intimates.

II. Literature Review

A. The Major Theoretical Perspectives

Disciplinary theoretical development has been influenced by the diversity of approaches to intimate partner violence. While there is considerable strength in approaching a social issue from a multidisciplinary perspective, there has been no synthesis regarding this subject (Gelles and Loseke, 1993; Ohlin and Tonry, 1989; Steinman, 1991). The field of sociology and family studies in specific began to focus on "family violence" (Straus, 1971; Gelles, 1974) just at the time functionalism was being questioned and dismissed as a research conceptual framework. The politically tumultuous era of the Vietnam War, the Civil Rights Movement, and consequently the Women's Movement were part of the catalyst for theoretical change in Sociology. Family sociologists were some of the first academics to look at violence and therefore, their theoretical perspectives dominated the world of academia (Yllo, 1993). These sociologists, led by Murray Straus and Richard Gelles in the early 70's, conceptualized family violence as a form of conflict. Like other sociologists of their time, Straus and Gelles bypassed functionalism and turned towards conflict frameworks to explain violence. Both Straus and Gelles have restated and revised their theories of violence but still, conflict remains the basis for their now meta-level conceptual framework (Yllo, 1993).

Before family researchers began theorizing about violence, advocates for battered women played a major role in understanding family violence. The advocate's position on intimate partner violence is not based within any one academic discipline, but rather was born out of the empirical perceptions of activists that women are subject to violence due to patriarchal systems (Dutton, 1994). These frameworks (also known as the feminist perspective) is a "*label applied to a subgroup of individuals who can be found in any discipline*" (Yllo, 1997; page 24).

Research methods were influential in the formation of the two primary and often opposing domestic violence perspectives. These two frameworks are extremely different and rooted in the fact of their different measurement and methodological approach. Within each framework are multiple theories. The first group of theories are referred to as (1) the *Family Violence Perspectives* and the other are the (2) *Feminist Perspectives* (Kurz, 1989). The Family Violence Perspectives focus on family systems while the Feminist Perspectives focus on why men use force against women. "*There is no unified feminist perspective on wife abuse*" (Bograd, 1988. p 13) but rather there are common themes found in the wide variety of feminist philosophies.

Family Violence theories are sometimes referred to as the *Sociological Perspective of Family Violence.* However, several widely used sociological theoretical developments are used to explain family violence. The commonality of the Family Violence theories is that the focus is on the "family" and incorporates other forms of violence such as elder abuse and child abuse. Family violence theorists traditionally were *Sociology of Family* researchers with an interest in family violence.

The Feminist Theories focus on intimate partner violence and violence that is perpetrated against women by men (Chapman and Gates, 1978; Dobash and Dobash, 1979;Martin, 1976; Pagelow, 1981; Russell, 1982; Schechter, 1982; Walker, 1979, 1984). In addition, feminist theorists focus on the general trends of men using force against women within historical, social, and cultural contexts. This chapter will highlight those Sociological theories to be tested in this study, which also happen to be the most dominant and the most heated debate regardless of disciplinary approaches.

1. The Family Violence Perspectives

Domestic violence research grew out of the research of family scholars who were interested in a variety of family conflict issues. Straus (1971) and Gelles (1974) designed a research agenda based on interviews regarding family violence. In 1975 and 1985, national surveys of adult populations were used for the exploration of domestic violence. By quantitatively analyzing the data, the commonalties were focused on for the Family Violence Perspective. These researchers based their theory on the frequency of violence, the roles of stress, and the norms that accept violence in some forms within the family context. The major family violence sociological theories include:

a. General Systems Theory

Family violence is a product of the family system (Straus, 1973; Giles-Sims, 1983). The violence itself is not seen as a result of individual factors as many accepted psychological theories suggested (Bersani and Chen, 1988). Straus (1973) modified

Scheff's (1966) theory of family systems to explain family violence. Straus created eight propositions of family violence (Bersani and Chen, 1988):

- Violence between family members has many causes and roots. Normative structures, personality traits, frustrations and conflicts are only some.
- Much more family violence occurs than is ever reported.
- Most violence is either denied or considered normal.
- Stereotyped family violence imagery is learned in early childhood from parents, siblings, and other children.
- The family violence stereotypes are continually reaffirmed for adults and children through ordinary social interaction and the mass media.
- Violent acts by violent persons may generate positive feedback, that is, these acts may produce the desired results.
- Use of violence, when contrary to family norms, creates additional conflict over the original violence.
- Persons who are labeled as violent may be encouraged to play out a violent role, either to live up to the expectations of others or to fulfill their own self-concept of being violent or dangerous.

Both Straus and Giles-Sims (1973 and 1983) suggested that the established family system could impact increases and decreases in the level of violence.

b. Resource Theory

Supporters of this perspective suggest that violence or the threat of violence is always present in the family system. Violence is driven by the resources, or lack there of. According to William Goode (1971) individuals within the family may use violence as a means to problem solving when they are lacking in resources. Goode (1971) suggested that family systems are power systems and that husbands can contribute more resources to a marriage, giving him the dominant position. However, he also contended the violence itself was inversely related to the amount of resources because as the assailant increases his access to resources, the less he may need to force his partner (Bersani and

Chen, 1988). Goode's theory predicts persons of lower economic strata are more likely to use force on their partner (1971).

c. Exchange/Social Control Theory

Richard Gelles (1983) describes violence is controlled by costs and rewards, meaning violence is used when the costs are fewer than the rewards. Furthermore, Gelles suggests that because violence is socially sanctioned in our society many of the potential costs have been removed.

Social control theory has frequently been used to explain juvenile delinquency as it purports that committing crime is just a part of human nature (Nettler, 1978; Vold and Bernard, 1985). Exchange theory assumes that every human act is either to gain rewards or avoid negative consequences (Blau, 1964; Homans, 1961). Gelles (1983) combines exchange theory with social control theory in what he views as a middle range theory such as Merton (1967) advocated. Gelles argues that the contribution of exchange theory to family violence is family members will use violence if the negative consequences of being violent are not greater than the benefits. In addition, the contribution from exchange theory to the explanation of family violence is the violence will occur without sufficient social controls in place. Gelles states, "People hit and abuse other family members because they can" (1983, page 157).

d. Subculture of Violence Theory

This sociocultural explanation of violence posits there are certain subcultures within our society where violence is more normalized than other sectors (Wolfgang and

Ferracuti, 1982). Wolfgang and Ferracuti (1982) find violence is more based on a culture than on social-structure. Therefore, certain subcultures will be more prone to violence and will be acting as expected for that particular subculture. Violence is seen as normalized within that group's collective values.

2. The Feminist Perspectives

The feminist perspectives began with advocacy for victims of battering before developing into a research theoretical framework (Dobash and Dobash, 1979; Martin, 1981; Roy, 1976; Walker, 1984). Theoretically, the feminist perspectives emphasize the historical traditions of the patriarchal family, contemporary constructions of masculinity and femininity, and structural constraints that make escape difficult for women who are systematically beaten (Johnson, 1995).

Curtis (1986) emphasizes that sociologically, authority is the most important source of power and is the driving force of patriarchy. Ultimately, males have the authority to control the family setting. Gender inequality is supported structurally. Bersani and Chen (1988) stated the reluctance of social institutions to intervene and prevent is reflective of the patriarchal structure. Martin (1976) found violence against women is fitting with patriarchy because "*The economic and social structure of our present society depend upon the degradation, subjugation, and exploitation of women*" (page 15).

Feminist theorists visualize domestic violence as a product of patriarchal traditions of men's right to control their women. It involves the "systematic use of not only violence, but economic subordination, threats, isolation, and other control tactics"

(Johnson, 1995: page 284). This violence is continuous physical, psychological and intentional. Johnson (1995) who refers to this type of violence as patriarchal terrorism states the "attention on the systematic, intentional nature of this form of violence and forces us to attend routinely to the historical and cultural roots of this form of family violence" (page 284). Clearly stated, subscribers of the feminist theories identify the causes of domestic violence as rooted in the larger societal structure. While these perspectives certainly cross disciplinary boundaries, the structural nature of the feminist perspectives are in keeping with sociological tradition. The feminist theories are rooted in a variety of philosophies, however, there are several constants. Bograd (1988) cited four major commonalties in the feminist theories while acknowledging vast differences. Those common dimensions are:

a. The constructs of gender and power

Feminist theorists view an act of violence within the social context and not as an isolated or individual event. Patriarchy as a structural issue is seen as the strongest underlying factor in woman battering at the personal level. Physical violence is an effective means of maintaining domination of women by men. Furthermore, even those males who are not personally violent still benefit as a class from the restriction placed on women.

b. Family as a historically situated social institution

The family must be examined within the cultural and structural context of a given time and place. Woman battering is a common event and is NOT rooted in the breakdown

of family functioning. Rather, violence against women is normalized in a patriarchal society where families are isolated and there is a greater division of private and public life. Furthermore, strong genderized roles have developed that bind women to men legally and morally (Breines and Gordon, 1983; Dobash and Dobash, 1979; Martin, 1976; Schechter, 1982) which reinforces the control men have of women.

c. Validating women's experience

Feminist theorists assume that male domination influences everything from behavior and attitudes to theoretical development. Under these circumstances, women's experiences may be seen as invalid. The feminist perspectives explain the experience of battered women from their own frame of reference and critically examines other theoretical development that incorporates victim blaming, minimizing, and devaluing.

d. Employing scholarship for women

The feminist theoretical development in violence against women originated in the activism of the battered women's movement of the early 70's. To this end, feminist scholarship is dedicated to the advocacy for women in addition to being the study focus.

B. Limitations of Theoretical Perspectives

1. Female on Male Violence

Research, conducted by Straus (1971) and Gelles (1974), supported the Family Violence Theories. Results from their survey research suggested women and men are nearly equal in their initiation of partner violence. Feminist scholars rejected the notion

men and women equally initiate violence because it was only women victims they were finding at the domestic violence shelters, in the hospital emergency rooms, and in the legal system. Straus (1971) and Gelles (1974) failed to measure the context in which female violence is initiated. For example, a woman may strike her male partner first if she perceived herself facing serious harm that she would be unable to avoid (Browne, 1987; Jurik, 1989; Jurik and Gregware, 1989). In fact, a battered woman may kill her partner when he is not attacking her (Browne, 1987). As Straus (1993) admittedly reports "who initiates an assault and who is injured are important aspects of the contextual information needed for a full understanding of the gendered aspects of intrafamily assault. For example, there may have been an escalation of assaults throughout the relationship with the original attacks by the man". Ultimately, female to male violence has been found to be much less physically injurious than male to female violence (Straus, 1986).

2. Conflict based

The family perspective is limited because it is based on Conflict theories which do not characterize the gendered nature of conflict (Yllo, 1993). Instead of violence based on a conflict of personal agendas, evidence suggests that the violence is a control tactic to maintain the husband's power (Bograd, 1988; Hanmer and Maynard, 1987; Jones and Schechter, 1992, Ptacek, 1988). The conflict perspective also suggests purposeful battering to gain resources or control or as a response to a situation when clearly, there is evidence some males plan an assault in advance and look for an excuse afterwards (Edleson, 1992).

3. Broad Generalization

The Family Violence theorists also do not envision spouse abuse as having a distinct etiology from child abuse or elder abuse. Feminist theories are not generalizable to all of family violence like the family perspective, however, there is insufficient evidence all forms of family violence should be analyzed jointly.

4. Ageism

Many researchers have speculated intimate partner violence decreases with age, which is based on methodological findings (Pillemer and Finkelhor, 1993). Gelles (1993) found that violence was primarily concentrated in ages 18-30. This assumption is based solely on self-report, and therefore, mitigating factors are being overlooked. For example, is it that violence has decreased with age or has the victim, over time, learned to minimize physical attacks by backing down from confrontations or avoiding potential confrontations by keeping quiet, submissive, and hiding. There is a large void in the domestic violence literature addressing later life violence. In fact there is no evidence declining rates of violence among older women are caused by a reduction in violence by the male partner or an increase in desistance by the female partner. Also, older women are less likely to be involved in relationships than younger women due to lower life expectancy of males and the American tradition of marrying older men. In sum, there are fewer males than females. The sex ratio of females to males increases with each older age cohort (Demographic Yearbook, 1996).

5. Sampling Error

Finally, the family perspective is based on findings from large-scale national surveys. Logically, the dynamics of domestic violence may largely preclude victims from participating in surveys. Coercive control over women by their mates follows some well documented patterns such as 'Controlling what she does, who she sees and talks to, what she reads, where she goes, limiting her outside involvement' (Schechter, 1988). Women who live under such a system of control and domination are not likely available for sociology research studies. These victims are not represented in those family violence surveys. Johnson (1995) finds evidence that the number of respondents who reported using shelter services is far lower than percentage of females using shelter services.

6. Univariate Explanation

Feminist theory is limited because it uses only patriarchy to explain domestic violence, which is a complex issue. Domestic violence may have multiple etiologies that a more complex theoretical model could explain. Some feminist studies are beginning to embrace more complex explanations of woman battering, but the progress has been slow in part by methodology.

7. Clinical Fallacy

Feminist research originated from the battered women's movement, the perspective of these early researchers were traditionally based on observations of women in shelters and emergency rooms. Feminist researchers often focus on smaller clinical studies, which produce clinical fallacies. Research conducted in the shelters may not be

generalizable to the whole population although it may be a powerful framework to describe the dynamics of violence and experiences of the population they serve.

III. Methodological Barriers Impede Theoretical Development

The methods are lagging behind recent theoretical advancements in the field of Sociology (Tickamyer, 1996) and without progress in the methods, the theory will not self-actualize. For Sociologists, social reality and theory are closely tied to each other. We derive our research questions from social reality and use theory to explain what we find. Methodology allows us to test our hypotheses to establish our theory creating an intrinsic dependence. Theory establishes the demand put on the methods. Sociologists theorize but are unable to critically examine theory with limited methods. If there is theoretical development, the theories cannot be critically examined with limited methodologies. Practitioners do not find intimate partner violence theories reflective of the social reality. These theories are difficult to challenge without better methodologies. As stated by Joseph Weis (1989), "*insufficient attention has been given to methodological issues that need to be investigated and resolved before more valid and reliable estimates of the prevalence and correlates of family violence can be expected.*" The methods are intermediary between social reality and theory. Tickamyer (1996) suggested the most critical shortcomings in the discipline of Rural Sociology were not in theoretical validity, but rather the 'problem lies more in the inadequacies of data conceptualization, production, and collection.' Methods encompass issues of sampling, measurement, definition, techniques and operationalization. These shortcomings in methodology have impeded development and testing of theory.

IV. Research Methodological Challenges in Sociology

Populations can be "hidden" from researchers because of unawareness or because of covert or illegal behaviors (Hay, 1997). Population estimations also depend on the methodology used and the accuracy and availability of the data (Hser et al., 1992; Rhodes, 1993). Brecht and Wickens (1993) suggested a fixed set of rules for population estimation is inappropriate because the "reality of the research contexts varies and never achieves a perfect fit with mathematical models" (Barnes, 1995).

Due to difficulty in collecting and measuring information on covert and illegal activities such as intimate partner violence, there is no one data source available for completely accurate data on prevalence. The victims are hidden and their perpetrators are involved in illegal activity (Browne, 1997). Neither a census nor a sample would capture this invisible population. Traditional methodologies are limited in this scenario and therefore, we turn towards a technique employed by wildlife researchers - - Capture / Recapture (Boukhout, 1994; Schemnitz, 1980, Seber, 1993).

The Department of Natural Resources, responsible for estimating wildlife populations, coined the term capture/recapture because they literally capture their subjects of study (deer and other wildlife), release them, and capture a second sample. Capture / recapture uses the information from the overlapping cases to estimate the invisible cases that do not appear in any of the data sources (Bishop, Fienberg, and Holland 1975).

V. Solution to the Problem

Women in physically abusive relationships belong to an invisible hidden population (Browne, 1987); therefore, the limitations of violence research and their problems with validity and reliability (Koss 1993; Johnson 1995) formed the problem and the research questions to be analyzed for this study. Capture-Recapture is an option for researchers who have been unable to identify invisible populations. By using Capture-recapture, we enhance our statistics and establish robustness. Capture-recapture will allow for the development of theory by providing a population size. We cannot examine all parameters of intimate partner violence and elicit a developmental pattern unless we can establish the sample first. This study will establish a viable and appropriate technique necessary to test hypotheses and therefore, support the theoretical development and refinement. A false positive or a true negative will mislead the researcher's conclusion and lead to erroneous theorizing. Methodological outcomes are extremely influential in providing a framework in which to develop theories by testing hypotheses based on social observations.

VI. Research Significance

This study will explore creative new methodologies to be implemented by Statistical Demographers for counting invisible populations. Before sociologists can qualitatively examine the structural causes and implications of an issue such as intimate partner violence to develop theoretical frameworks, they must first be able to identify the victims and persons at risk. The prevalence of spouse abuse among couples cannot be

derived from face to face interviews or any other formally structured interview. Due to the nature of the topic, as will be discussed in great detail, people are generally reluctant to admit they are victims of domestic violence due to fear, loss of status and embarrassment.

There are many elusive and hidden populations that need to be counted to establish their social significance. Two recent examples of the practical application of capture / recapture research were on prostitution (McKeganey et al. 1992) and homelessness (Fisher, et al. 1994). The capture / recapture technique is being explored in epidemiological research, however, has rarely been applied to social research, and never in estimating the prevalence of victims of intimate partner violence.

The application of this technique in sociological research pushes the general knowledge about demography ahead. This use of the capture / recapture technique is taking an old technique and utilizing it in a novel manner for sociological research. This use of the capture / recapture will provide a precedence for social researchers by providing them with a new method of indirect estimation. In fact, this methodology can be used when social scientists have found enumeration to be impossible. This technique could create a paradigm shift in the way researchers do their counting by providing widespread, accurate, and cost effective means to estimate the size of certain populations (LaPorte 1994).

This methodology will open up the framework for theoretical development and may change how we approach domestic violence. This research increases the "body of sociological knowledge" by expanding our conception of domestic violence and by establishing the persuasiveness of intimate partner violence, who the victims are, and

their characteristics. This technique can help to test existing theoretical frameworks of violence between intimates.

This study will begin to look at the impact violence has on older populations as compared to younger populations. Although, detailed information surrounding the abuse of the older woman is beyond the scope of this study, we may see the incidence of violence among the elderly is much greater than found in previous research. We will see the frequency older victims of intimate partner violence present themselves to police departments, prosecutors, domestic violence shelters, and emergency rooms.

This research provides a framework for the beginning of sociological theory on intimate partner violence according to age. This topic is timely because this country's average age is quickly rising. Soon, the baby boomer age cohorts will reach the elder years and Michigan (and The United States) will have a disproportionate number of senior citizens (Office of the State Demographer, 1995). Domestic violence among the elderly is of great importance when so many Americans are in the older age brackets (Office of the State Demographer, 1997) and are still victims of intimate partner violence. Based on the current American population structure, intimate partner violence among older couples will be even more of a social problem in the near future because there will be more "at risk" women.

This study will determine if men are as likely to be battered as women and if there is supporting evidence that women are as likely to be perpetrators as men. Determining the gender role in violence will resolve the conflict between the feminist theorists and the family violence theorists.

This research provides a departure from traditional enumeration methods. Historically, demographers approach to counting human populations is to count and classify every person of interest (LaPorte, 1994). This study will demonstrate how it is better to take an incomplete list of accurate information for population estimation than broad based inaccurate data as in a census or a large scaled survey.

This research serves as an evaluation tool for service providers of victims of domestic violence by determining the percentage of women missing from their registries. Furthermore, this research will demonstrate the overlap and dependencies between services of the various agencies. There are increasing trends for communities to combine the efforts of multiple agencies to reduce and prevent domestic violence and this research will show to what extent those agencies overlap. For example, shelters encourage women to report their cases to the police departments and these results will demonstrate to what extent women present to the different agencies. This information will prove useful in program development and community collaboration to better help victims.

Finally, improving violence research methodologies is sociologically significant because it can establish "suggestions about how to reduce the extensiveness and severity of social problems" (Zastrow, 1992). To this end, it is important to identify the special needs of victims by identifying their characteristics and the etiology of intimate partner violence. A more accurate depiction better prevents intimate partner violence and can aid in the development of intervention programs by government and policy-makers.

CHAPTER 2 – METHODS AND TECHNIQUES

I. Research Application

There is substantial power of a research design built on multimethodology for addressing significant social problems like domestic violence. Traditional methods cannot sufficiently estimate the magnitude of violence in our population. Therefore, appropriate and creative techniques are required to evaluate effectiveness of control strategies, to monitor changes in the nature and severity of domestic violence, to identify additional research needs, and finally, to facilitate planning for prevention and intervention strategies. This research bears tremendous social responsibilities in effectively addressing the intimate partner violence (IPV) social problem. To this end, interdisciplinary estimation techniques applied to epidemiological and fisheries and wildlife studies will be put to the challenge in this intimate partner violence research study.

II. Research Questions

This study will involve measuring relative prevalence (number of victims within a relative time frame) and incidence (number of assaults experienced by victims) through the Capture-Recapture technique and will be used to test the following research questions:

Research Question 1: Can the capture-recapture technique indirectly estimate the size of an invisible population?

Research Question 2: Are there significantly more cases of domestic violence than are reported or estimated from surveys?

Research Question 3: Does older couple violence compare to younger couple violence?

Research Question 4: Are women as likely to perpetuate violence as men?

Capture/recapture is an exciting new methodology that is promising to researchers as a means for estimating the size of invisible and elusive populations. However, there is a polarization of estimation researchers into two groups - - those who believe capture / recapture is the all encompassing answer to demographic shortcomings and those who find the technique enticing as a cure-all but who nonetheless are skeptical about the ability of the technique to accurately measure social phenomena (Hay 1996). LaPorte (1994) contends capture / recapture will change how population estimation is conducted in all disciplines. In contrast, Hook and Regal (1995) and Hay (1996) are more reluctant about capture / recapture estimates due to the unknown estimation precision of the technique. This division in the literature of capture / recapture critiques may be reconciled with simulations and statistical controls.

To answer the first research question, a feasibility study will be conducted on capture-recapture. The study will include a demonstration of how the statistical process is able to indirectly estimate a population size and whether the technique is viable outside of a theoretical model. A simulation study will be used to test the sensitivity of the technique by extracting random numbers from a matrix and imputing them into sample size and duplication cases. From the simulation it will be possible to demonstrate how close the capture-recapture estimates come to a known population size in a controlled experiment.

The simulation will produce a distribution of the population estimates derived from capture/recapture in order to predict how close the estimates lie in relation to the

known population size. The simulation model will demonstrate what happens to the estimates with varying probability of being captured and varying overlapping of sample sizes. The simulation model will convey how "sensitive" the capture-recapture equation is to sample size. Finally, the simulation will be used to estimate the precision for independent models.

To answer the second research question, current domestic violence rate estimates will be compared to the rates derived from the Capture / Recapture technique to determine if there are significantly more cases derived from the new statistical technique. We assume the capture / recapture technique will yield an estimate closer to the true population size than those derived from single sources or from surveys. Therefore, if the capture / recapture estimates are larger than previous estimates, we will assume that indeed intimate partner violence affects a larger portion of the population than previously suspected.

Since there is no way to know how many persons are victims of intimate partner violence, current statistics are derived from surveys. Victims remain invisible in research because they refrain from self-identification in surveys and field studies (Pillemer and Finkelhor, 1988; McPherson, 1990; Vinton, 1992). For comparative purposes, rates will be derived from the Violence Against Women Study conducted by The Gallup Organization for the state of Michigan in 1996 and also from the National Family Violence Survey and the National Crime Victim Survey.

The third question will be answered by comparing the prevalence of intimate partner violence between older and younger women to see if there is a significant difference in rates of abuse. In addition, the capture-recapture technique will be used to

determine if older women are more invisible than younger women from institutional registries. This will be determined by estimating the prevalence according to age and finding the proportion of observed or "captured" women according to age. The proportions between older and younger women will be compared to determine what proportion of the population is not accounted in the estimations.

Finally, the prevalence of female-on-male and male-on-female violence we be compared to determine gender differences. Again, the capture-recapture technique will also determine which gender is more elusive to the prosecutor's office, police departments, hospitals, shelters and outreach programs for Marquette County.

III. Operational Definitions

Intimate Partner Violence is the threatened or actual intentional use of physical, sexual and/or psychological/emotional force against a person. This includes the physical and emotional assault or stalking of a woman by former or current partners. Commonly referred to types of behavior that fit within this definition include domestic violence, interpersonal violence, intimate partner violence, partner violence, wife battery, spouse abuse, marital rape, stalking an intimate, violence in a dating relationship. For purposes of this research study, only physical violence will be measured because these data are based on physical evidence of violence. However, in no manner should it be inferred that by excluding emotional and psychological violence from this study those non-physical forms are any less traumatic or more humane to the victims. Verbal Aggression may be more damaging than physical attacks (Vissing et al., 1991). "One can hurt a partner deeply – even drive the person to suicide without lifting a finger (Straus, 1993; page 68).

The exclusion of non-physical violence from this study indicates a limitation of measurement capabilities and an area for further research in the future.

Intimate Partner Violence (IPV) is often interchanged with domestic violence or spouse abuse, however, it includes the forms of domestic violence as described above. The "intimate" indicates current or former relationship of a sexual nature. The term intimate partner violence is preferred to domestic violence because it encompasses victims trying to leave their partner. Also intimate partner violence categorizes similar types of violence that may be excluded when only focusing on wife battering or spouse abuse.

Older women are considered all women over the age of forty years for this research study. Forty and older have been selected as an inclusion criteria because dichotomizing the population at this age still allows for sufficient sample size in the older category while still distinguishing a difference between women in their child-bearing years verses women with completed fertility. Women with small children are generally the preconceived "typical victim" of domestic violence and face obstacles specific to their age group. This study seeks to also identify the nontraditional victims of domestic violence to see if patterns and structures exist in this age cohort like their younger counterparts.

IV. Capture / Recapture

The Capture-recapture method is derived from the practice of randomly sampling a defined population, marking the captured sample members for later identification purposes, then releasing those captured back into the population. A second random

sample from the same population is taken and the proportion of marked individuals from the first sample found in the second sample is assumed to be the same as the proportion of marked sample members in the defined population (Barnes et al. 1995). Multiplication of the two sample sizes divided by the number found in both samples results in an estimate of the total population of interest (Bishop, Fienberg, and Holland, 1975). The strength of capture/recapture is that while it adjusts for any individual source not containing all cases, it generally assumes that the cases a source does contain are truly cases. According to Hook and Regal (1995) Capture – Recapture has been applied to human population research for four major applications. First, to estimate population size when there is clearly incomplete data available from two or more sources. Second, refinement of estimations derived from surveys. Third, evaluation of registries; and fourth, deriving plausible upper or lower limits on the total affected population in confidence intervals. The Department of Natural Resource methodology was justifiably used for the four aforementioned reasons in the proceeding literature. (Abeni et al.1994; Alho 1990; Barg and Huether 1983; Benn et al.1975; Bishop et al. 1975; Bloor et al. 1991; Bobo et al.; Brecht and Wickens 1993; Bruno et al. 1982; Chapman 1983; Chiue et al. 1993; Cochi et al. 1989; Davis et al.1993; Doscher and Woodward 1993; Drucker and Vermund 1989; Espeland et al. 1988; Fisher et al. 1994; Frischer 1992; Frischer et al.1991 ; Goldberg and Wittes 1978; Gutteridge and Collin 1994; Hartnoll et al. 1985; Hewitt and Milner 1970; Hilsenbeck et al. 1992; Hook and Chambers 1980; Hook et al. 1982; Hook 1993; Hook and Regal 1992; Hser 1993; Huether et al. 1981; Kehoe et al. 1992; Kozinetz et al. 1993; Laporte et al. 1992; Lewis and Hassanein 1969; Lie et al. 1994; Mastro et al. 1994; McCarty et al. 1992; McKeganey et al. 1992; Modesitt et al.

1990; Neugebauer 1984; Newmeyer 1988; Palfrey et al.1994; Prevots et al. 1994; Robles et al. ; Rubin et al. 1992; Sachs et al. ; Schouten et al. 1994; Serrano Rios et al. 1990; Sutter et al. 1990; Sutter and Cochi 1992; Taylor 1989; van Haastrecht et al. 1991; Walter et al. Watts et al. 1994; Wickens 1993; Wittes 1968; Wittes and Sidel 1968; Wittes et al. 1974; Woodward et al. 1985; and York and Madigan 1992). Neugebauer and Wittes (1994) described the Capture-recapture method as helpful in that it "openly acknowledges that data collected on a regular basis leaves out a large proportion of the population of interest".

In one of those epidemiological studies Mastro et al. (1994) utilized the capture / recapture technique to estimate the number of injection drug users in Bangkok. Until this research project was implemented, public health workers in Bangkok suspected much higher rates of heroin use than were detected in survey data and/or institutional data. Higher rates were suspected because public health researchers were able to determine the percentage of heroin users who were HIV positive. The number of HIV cases increased more than the reported number of heroin users. Capture-recapture was used by Mastro et al. to count those cases missed by direct estimation procedures. Using the capture recapture technique, an additional six thousand heroin users were identified. These results reflected the increase in HIV cases that were known to be contracted from heroin usage.

V. Capture / Recapture in Wildlife Population Estimation

Using the example for estimating the number of deer in a designated area, a sample of n_1 deer are captured, tagged, counted and released back into the woods. A second sample of deer, n_2, are then caught. The number of recaptured (m) deer is counted

and is also known as the overlapping population. The proportion of tagged deer in the second sample is m/n_2 which is assumed to be the same as the proportion of the sample to all of the deer in the whole forest, n_1/N. Thus, the number of deer in the whole forest, N, is estimated (Neugebauer and Wittes 1994) as[1]:

$$N = (n_1 * n_2) / m$$

For example, if 100 deer are captured at Time 1, and released and then 100 more deer are captured at Time 2. Five of the deer at Time 2 also had been captured at Time 1, meaning that 5% of the population from Time 1 was recaptured at Time 2. The proportion of recaptures at Time 2 represents the proportion of the Time 1 sample to the whole deer population. Thus, we can summarize the 100 deer captured during Time 2 equal 5% of the entire deer population. Therefore, we can estimate the total deer population to be 2000.

$$N = (100 * 100) / 5 = 2000$$

Members of a population are "captured" by appearing in one data source or "list" and are "recaptured" by appearing again in another list, or by "matching." They are "tagged" by virtue of having an identifier where they can be traced from one "list" to the next. The "lists" are matched against each other using the unique identifier and the matches between two lists and three lists are then counted m. Using these numbers and the formula referenced above for a two-source estimation of population (Geiger and

[1] This equation is based on the assumption of independence.

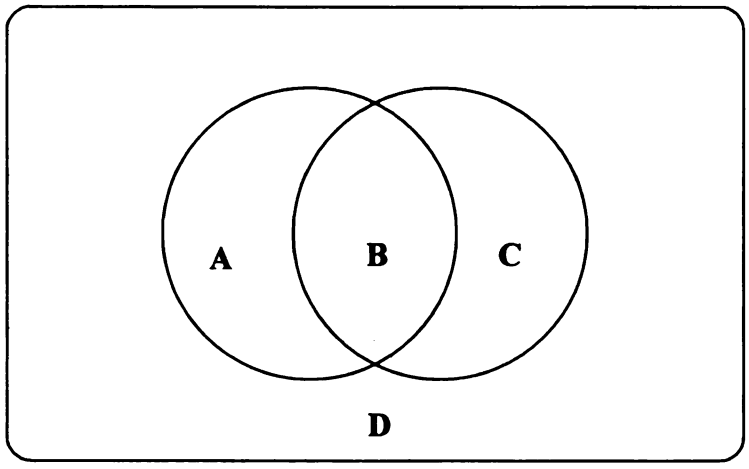
Werner, 1924; Sekar and Deming, 1949), the number of the total population of IPV victims can be estimated.

There are some rare events when demographers used capture / recapture in the distant past. Currently, this technique is not in mainstream demography, however, is being reintroduced to the field because of its unique ability to calculate indirect population estimates. In 1949, Sekar and Deming used the capture/recapture method to estimate birth and death rates and the extent of registration. Their paper may be regarded as the first serious application of the capture-recapture method to human health, and provided a good discussion on some of the practical problems associated with the method. Shapiro (1894) applied the technique to birth registration in the United States, using census data. By taking another source in addition to the census, the capture-recapture method was used for estimating undercounts in vital statistics. The census of 1950 utilized capture-recapture to estimate the undercounting (Nanan and White, 1997). It was referred to as 'dual system estimation' (Nanan and White, 1997; page 145). This system has also been used in the following census counts as part of the "post-enumeration survey" to estimate the undercounting and the relative under-enumeration of particular minority and poor groups (Nanan and White, 1997; page 145). The US Census Bureau has proposed using capture-recapture as part of its statistical sampling and analysis for the 2000 count because it will reduce costs. The US Census has also cited, as its rationale for using this technique, that the US population is not a small sedentary population where a door-to-door survey is more appropriate. Reluctance to use capture-recapture for estimating the undercounts has faced barriers not in the methodology, but rather in the

political ramifications of reapportionment of House of Representative seats (Nanan and White, 1997).

VI. Capture / Recapture Applied to Marquette County

Figure 2.1 Two Sample Database Overlap



The simplest capture-recapture model is the so-called two-source model, applied to estimate the unknown size of a population. The first source (A) provides the individuals for marking or tagging and is returned to the population (rectangle), while the second source (C) provides the captures at Time 2. Using the numbers of individuals caught in both sources (B) (the recaptures) and the numbers caught in just one source (A-B or C-B), it is possible to estimate the number not caught in either source(D), thus providing an estimate of the total population size, N.

The capture-recapture method can, in principle, be applied to any situation in which there are two incomplete lists (International Working Group for Disease Monitoring and Forecasting, 1995). One simply replaces "being caught in source (A)" by

"being on list (A)." This is the case in Epidemiology where lists can be constructed from a variety of sources such as hospital records, doctors' medical files, medical prescriptions, and so on. These lists are incomplete by their very nature, and the problem is to estimate those missing from both lists. Incomplete list estimation, (also known as *incomplete case ascertainment)*, is an excellent scientific method borrowed from wildlife ecologists and public health researchers.

Capture-recapture is perfectly suited for indirectly estimating the prevalence of intimate partner violence in this dissertation. Victims of intimate partner violence are elusive and are not exhaustively reported to any one institution. However, there are several agencies where cases of intimate partner violence ARE reported. These lists are merely "incomplete" albeit true. For example, the women who report to domestic violence agencies are true cases of intimate partner violence, however, not all women seek shelter after violent encounters with significant partners. Therefore, the list of cases from a shelter is said to be "real cases" as well as incomplete. Capture-recapture is applicable in situations where missing cases are a factor. Capture-recapture can operationalize the overlap of two or more "incomplete" lists of data as long as the cases are identifiable and the number of cases per list is known.

Applying this technique to the Marquette population, every case (N) of intimate partner violence is located within the rectangle. This includes cases reported in the medical reports, police reports, shelter cases, and outreach cases, AND those cases that were never reported. A and C, the lists according to institutional data sources, will link identical cases together through identifiers (first and last name and/or address). Those cases that are linked (B) will be used to estimate the unknown cases (D).

There is an alternative method for estimating the invisible population by arranging the observed data in a 2 by 2 table with one missing cell (Fienberg, 1972). Estimating the missing cell using contingency tables lends itself well to increasing the number of data sources and using more complicated models (as will be discussed in greater detail in Chapter 4). The invisible population is then added to the observed population to estimate the total population of a given phenomenon. This technique was independently created by two different researchers, Petersen (1896) and Lincoln (1930), because it is so intuitively logical. Hence, the technique is often referred to as the Petersen estimate or the Lincoln index (Fienberg, 1972).

VII. Satisfying the Necessary Assumptions for Capture / Recapture

For applying the capture-recapture estimation method, several assumptions are required.

Assumptions:

1. There is no change to the population during the investigation (population stability).
2. For each source, each individual has the same chance of being included in the source (catchability).
3. The two sources are independent.
4. Positive identification of true cases and accurate matching.

Continuing with the discussion of the capture-recapture method from the two-sample model with sources 1 and 2. This example taken from the International Working Group (1995) assumes that m_{11} is the number of individuals captured in both sources, m_{22} is the number of individuals un-captured in either source, and m_{21} and m_{12} are the numbers of individuals captured in only one source. Therefore, "$m_{11}+ m_{21}+m_{12}$" is the number of

different individuals captured in two sources. Furthermore, assume that each individual has an equal probability of being captured; each individual has p_1 of being captured in source 1, and p_2 in source 2. Therefore, the expected numbers of being captured in two sources are:

$$E(n_1) = N * p_1 \qquad \text{Equation 1}$$

$$E(n_2) = N * p_2 \qquad \text{Equation 2}$$

$$E(m_{11}) = N * p_{12} \qquad \text{Equation 3}$$

Figure 2.2 Contingency Table of 2-Source Capture-Recapture

		Source 2		Total
		captured	un-captured	
Source 1	Captured	m_{11}	m_{12}	$n_1 = m_{11} + m_{12}$
	un-captured	m_{21}	m_{22}	
	Total	$n_2 = m_{11} + m_{21}$		$N = m_{11}+m_{21}+m_{12}+ m_{22}$

If we assume that the proportion of source 1 for the whole population is roughly the same as it is in source 2 (which is based on the assumption each individual has the same chance of being included in the source), then $(n_1/N) = (m_{11}/ n_2)$ and therefore the basic idea of capture / recapture (Petersen, 1896, Barnes 1995, Mastro 1994) is:

$$E(N) = n_1 * n_2 / n_{11} \qquad \text{Equation 4}$$

Simply stated, the expected total number of individuals is a function of the size of the first source and an adjustment factor, that is the inverse of the estimated level of ascertainment by the first source (IWG, 1995). Further equations can be derived from the original capture/recapture equation as derived in the International Working Group for Disease Monitoring and Forecasting (1995). Another way of writing this result, which is useful in the log-linear formulation described later (to adjust for an assumption violation), is

$$E(N) = (m_{11} + m_{21} + m_{12}) + E(m_{22}), \text{ where } E(m_{22}) = m_{21} * m_{12} / m_{11}.$$

Following this logic, equation four can be further transformed into:

$$E(N) = (N * p_1) * (N * p_2) / (N * p_{12}) = N * p_1 * p_2 / p_{12} \qquad \text{Equation 5}$$

A. Source Dependency / Independence

If the two sources are independent from each other, the degree of dependency, $R = (p_1 * p_2 / p_{12})$, should be equal or very close to 1, and then the expected/estimated N should be unbiased, equal or very close to the true total population size. If the two sources are dependent,

$$R = p_1 * p_2 / p_{12} = p_2 / p_{2|1} \qquad \text{Equation 6}$$

where $p_{2|1}$ represents the probability of an individual being in the second source given that she is in the first source. If being in the first source tends to increase the probability of being recaptured, then $p_{2|1} > p_2$, and R should be less than 1, and the estimated N will underestimate the true N. Similarly, if being in the first source tends to decrease the probability of being recaptured in the second source, the estimated N will be upward; over-estimated.

In the case of Marquette, the violation of the assumption of independence must be resolved. For example, there is dependency between medical and police files. Victims of abuse who have sustained injuries requiring treatment may present at the hospital. Health Care workers are required to report abuse cases to the police. While the victim did not report the incident directly to the police, the police become involved and file a report after being called in by the medical staff at the hospital. In this case, being captured in the police data is dependent on being captured in the medical data.

More technically stated: Any two sources A and C are independent if the overall probability of members of a population who appear in their intersection *P(A and C)* or the overlap (B) is equal to the product of the average *P(A*C)/ P(A and C)* probabilities of appearing in both A and B. When A and C have no cases in common whatsoever, then the probability of being in both of them is null. In contrast, if all of the cases of one data source are found in the second data source, then the probability of A (first data source) and B (overlap) being the same is 1.0. Dependency tends to produce "underestimates" (Hook, 1995). The assumption of independence may be tested with the use of log-linear techniques applied to multiple sample Capture-recapture models (Fienberg, 1998; Frischer and Leyland, 1992; Hser, 1993; Bishop et al., 1975).

Although independence must be sufficiently addressed, this proposed research is using three-factor capture-recapture in contrast to two-factor capture/recapture. When using the three-factor (lists) "the assumption of independence can be dropped, and interdependence among data sets can be accounted for by using Log-linear modeling techniques to assess source dependencies" (Nanan and White, 1987; page 145). Furthermore, when the number of cases contained on each list is large, the estimates are less sensitive to dependency of samples and catchability (Hook, 1995). However, for further explanation of controlling for violations of the necessary assumptions, see Chapter 4.

B. Population Stability

The third assumption is also controlled for by the catchability statistical controls because remaining in a population makes a case more catchable than one which is initiated by a person who has left the population. There are no populations that remain unchanged during the research period. Therefore, population stability is identified as the degree of "instability". Theoretically, there is constant out-migration and in-migration births and deaths; however, as long as the overall population size, calculated within a given time frame (1996), remains fairly constant, there is equal opportunity for the loss of perpetrators as well as in-migration of new perpetrators (given the example of domestic violence).

The samples used for this study were collected simultaneously which reduces the risk of violating the population stability assumption. If the samples were taken sequentially, which is the case in wildlife research, a sample is taken during one time

period and released. At a later time, a second sample is collected. There is room for inmigration, outmigration, births and deaths between the two sampling periods. In contrast, this research study examines data from various samples during the same time period. Therefore, even if there was some entering and exiting of captured persons, those persons still had the possibility of being captured in more than one sample. In the case of this research, three-factor capture recapture is being used and therefore, as described above, it is possible to install log linear controls for sample dependencies.

C. Catchability

The probability of ascertainment varies by any of the institutional sources. Catchability can be influenced because of geographic or socio-economic variables (Hook, 1995). The data must be modeled (similar to independence log-linear analysis) and tested for deviations from independence. Overall dependency or relative bias estimates can be explained as though they were calculated from sources with no variable catchability (Hook, 1995). Because the medical, shelter, and police database contain some data on perpetrators and victims of violence, it will be possible to control for likely causes of catchability. Items such as "age" can be used to estimate the population according to strata. If there are large differences between subgroups, the estimates can be calculated while adjusting for covariates.

D. True Cases and Accurate Matching

The technique of capture-recapture can only be applied in situations where there are known cases of the topic of interest. Although it is absolute that the data source is

incomplete, those cases in the database must be accurate. Furthermore, the cases must have sufficient identifiers to positively match all cases between data sources.

VIII. Validation of Capture / Recapture

Generating a simple capture / recapture estimate as a true population size does not stand alone as a valid measure of violence prevalence. All measurement is to some degree indirect and imprecise. When we try to observe a given phenomenon or behavior, we invariably must rely on indicators that are imperfect in two ways: at the level of conceptualization and at the level of measurement.

Even if we agree at the conceptual level on how to define abusive behavior, our actual measurements and indicators (validity) of such behavior are subject to error. For example, information about an individual's past record of spousal abuse may come from an unreliable source, may be missing from official records, or may be incomplete, inexact, or unverified. Thus, there is a certain risk that actual perpetrators will not be "captured" (or the individual may have been "captured" but there was insufficient evidence to demonstrate conclusively what was the nature or severity of the event or behavior). Furthermore, we may only have circumstantial evidence or trace evidence that a given event occurred; we may observe some of the consequences of some action but not the action itself. Because of the imperfections of records and available information, we need to be especially concerned about relying only on a single source of information. In addition, any single indicator of a complex phenomenon is likely to reflect only some aspect of that phenomenon.

Single indicators of intimate partner violence are invalid measures because of these threats of validity. Capture / recapture uses multiple sources and is an improvement in itself of these types of measurement error. However, we must demonstrate that capture / recapture is not only an improvement of "invalid" measures of violence, but is indeed 'a valid measure'. Capture / recapture is not sensitive to datasets containing missing cases, in fact it is a technique that adjusts for incomplete case ascertainment.

Scientists have long understood the importance of making multiple trials and experiments in order to test their hypotheses (reliability). Furthermore, because of the need to rely on indirect evidence and imperfect information, they usually seek to test their hypotheses using multiple methods and multiple indicators. The more a researcher is able to verify the phenomenon using multiple indicators and different methods, the more confidence can be placed in the observations. That is, the more valid the inferences or conclusions that are derived from empirical research, the more certain they can be of their conclusions. We often seek validation or corroborating evidence from second or third sources before we take action or draw final conclusions. For this reason, it is important to seek multiple and independent sources of information to verify that what we are observing is true and thus increasing the reliability of the methodology.

King et al. (1994) emphasized, "various ways in which we can increase our leverage over a research problem. The primary way is to increase the number of observable implications of our hypothesis and seek confirmation of those implications. Maximizing leverage is so important and so general that we strongly recommend that researchers routinely list all possible observable implications of their hypotheses that might be observed in their data or in other data."

Capture / recapture in essence is a form of methodological triangulation by calculating estimates from a variety of data-source combinations. In fact, Fienberg (1998) advocates profiling possible data combination capture-recapture confidence intervals for comparative purposes. There have been studies where the actual size of the population was known, however, capture / recapture was utilized on sub-populations to estimate the overall population (Hook, 1982). There is empirical evidence that using three or more sources provides reasonable estimates of the total population. Mastro (1995) found that when capture / recapture used at least three factors, the estimates were near that of known population sizes, while controlling for necessary assumption violations.

There has also been evidence that using the median estimate of a variety of source combinations provided a form of validation for the final estimation (Frischer et al., 1993). Internal validity is checked by comparing the estimate of one source, derived by assuming the other two are independent. For example, if we calculate prosecutor source based estimates, while assuming the other two (shelter and outreach) are independent. The estimate of only prosecutor source is used in a ratio with an estimate created only by the shelter and outreach. The ratio is an estimate of the relative bias of the three source estimate (Hook, 1995). Multiple source log-linear analyses that produce consistent results are more evidence of a valid estimate as will be clearly demonstrated in chapter 4.

IX. Relational Databases for Capture/Recapture Analysis

Capture / Recapture requires the use of "relational database analysis" as opposed to analysis on a flattened file. The major difference between flat and relational databases is the structure of data storage. The nature of relational databases enables them to link to

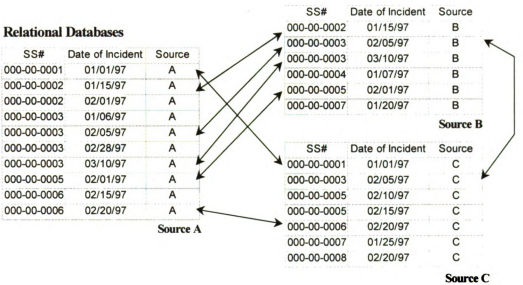
each other based upon one or more key variables. As you see below, the set of relational databases is linked together based upon three variables, social security number, date of incident, and data source. Here we use social security number for illustration purposes. Most social researchers use flat databases for analyses as pictured below. However, for purposes of capture / recapture the data must remain desegregated based on the referring source. Cases of intimate partner violence will be linked together according to identifiers (such as social security number or name) as shown in the relational databases below[2] (See Figure 2.2). When a set of relational databases is combined into a flat database it appears the flat database contains all the records because every incident is listed once. However, a part of information has been lost.

[2] Database illustration was created by Chun-Hao Li for 'Estimating Incidence of Family Violence in the USAF" by Wibert and Li, 1997.

Figure 2.3 Flap VS. Relational Database

Flat Database

SS#	Date of Incident	Source
000-00-0001	01/01/97	A
000-00-0002	01/15/97	A
000-00-0002	02/01/97	A
000-00-0003	01/06/97	A
000-00-0003	02/05/97	A
000-00-0003	02/28/97	A
000-00-0003	03/10/97	A
000-00-0004	01/07/97	B
000-00-0005	02/01/97	A
000-00-0005	02/10/97	C
000-00-0005	02/15/97	C
000-00-0006	02/15/97	A
000-00-0006	02/20/97	A
000-00-0007	01/20/97	B
000-00-0007	01/25/97	C
000-00-0008	02/20/97	C



By aggregating data into flat databases, a piece of very important information for the capture-recapture method is lost. In the flat database, only one data source is entered. The second and other data sources have never been identified in the database. For example, from the flat database, we are unable to tell that the incident which happened on 01/01/97 by the person, 000-00-0001, was also captured in both data sources A and C. As the figure shows, a set of relational databases looks more complicated and less organized than the flat database, however, relational databases store the complete information for the estimation capture-recapture method. Furthermore, based upon several key variables or identifiers such as name and address, the same records which appear in the different databases can be linked together. In short, the flattened database appears to contain all the records, however, to apply the capture-recapture method to estimate prevalence of intimate partner violence, the flat database is inappropriate and the relational databases broken down by the data source are necessary.

X. Population of Interest

The intent of this multi-methodological approach is to find prevalence and to identify the trends and nature of intimate partner violence in Marquette County.

A. Marquette County, Michigan

Marquette is the largest county east of the Mississippi River (1,841 square miles). It is located in the Upper Peninsula of Michigan on Lake Superior where the average snowfall ranges from seven to twelve feet per year (Hayse et al., 1998). The 1990 Census shows a total population in the county of 70,887. The city of Marquette, which is the

largest in the Upper Peninsula, has a population of 21,977. Northern Michigan University, with a population of 8,000 students, is located within the city.

The terrain varies from the ancient hills of the Huron Mountains in the northwest, to the extensive swamps and forests of the southern sections. The county has nearly 2,000 lakes and ponds, with 4,000 miles of rivers and streams. There is only one short stretch of divided highway. The majority of roads are old two lane county roads. There are 47 small isolated rural villages and cities with less than 1000 people (Hayse et al., 1998). Forty-three percent of the county population is designated rural.

K. I. Sawyer Air Force Base, which was a major employer of local people, has been closed down in the last decade. Iron ore processing is the county's largest industry and employer. The University and a large maximum-security state prison are also major employers. Education, health care, chemicals, lumbering, shipping, agriculture and tourism are economically important too.

Factors related to the difficulty of addressing domestic violence in Marquette include: The small-community atmosphere, where great care is taken to keep the crime hidden; and a poor economic base, which promotes financial dependence on an abuser. The sometimes-hostile terrain and extreme weather conditions, coupled with the rural setting and lack of transportation, can keep a battered woman isolated, adding to her fear and dependence on an abusive partner.

B. The Study

This study comes from the violence estimation portion of Marquette Research for Justice Violence Agencies (MR JAVA)[3] funded out of the Violence Against Women Act[4] funds via the Michigan Department of Community Health (Hayse et al., 1998). Marquette County was selected as the target population because of access to excellent data sources including Domestic Violence Shelter, Intimate Partner Violence Outreach Services, Hospital, Police, and Prosecutor data. Furthermore, the Department of Community Health has selected Marquette County for pilot research projects involving hospital data, medical examiner data and police/prosecutor data. The Michigan Department of Community Health and the Center for Disease Control have funded this research project to be completed in Marquette County making it convenient to also use the same data for these analyses. Furthermore, there will be access to confidential data with identifiers.

XI. Data

In estimating intimate partner violence experienced by women, institutional records in Marquette County will be used as the samples of persons captured and then recaptured. These records include domestic violence shelter reports, 911 calls, violence prevention outreach program records, prosecutor data, and police/emergency room reports. In this study a multi method approach will be employed, collecting quantitative data from general sources as samples for the application of the *Capture-recapture*

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[3] See http://vip.msu.edu/mrjava/index.html for details of project.

[4] The Violence Against Women Act (VAWA), passed as part of the Violent Crime Control and Law Enforcement Act of 1994, takes a comprehensive approach to domestic violence and sexual assault, combining a broad array of legal and practical reforms and will improve the responses of police, prosecutors and judges to these crimes, force sex offenders to pay restitution to their victims and increase funding for battered women's shelters. And, under the Act, the authority of a "stay away" order obtained against an abuser will no longer stop at the state line.

technique to establish prevalence and incidence. Also, qualitative data is collected on the victims to provide further characterizing information.

The first database is the prosecutor data. The second database will be those women who sought safety or went into hiding at the Marquette County Domestic Violence Shelter - - Harbor House. The third database comes from a Marquette Outreach program. Women come to the Outreach Program in order to receive counseling services, secure financial resources, and learn about the dynamics of power and control in order to prevent entering into another violent relationship and/or returning to their former batterer. The Outreach Programs are similar to the Shelter Program except that Outreach is non-residential. In Marquette County there are two Outreach Program offices. Those offices reside in the towns of Ishpeming and Marquette.

This research project will also use criminal justice and hospital data. When a victim presents in the emergency room, the hospital is mandated by law to report cases of domestic violence within the same day to the appropriate police department. It is impossible to obtain confidential data from the two hospitals in Marquette County; however, for this research, those data are collected by the reports which are made to the police departments. In turn, the police are mandated to file all reports of domestics within 48 hours to the prosecutor's office. In addition to reports made to the police department by outside agencies, the police are mandated by Michigan Law to make an arrest if the altercation is physical in nature. The officer has 48 hours to file a report with the prosecutor's office. These data are all substantiated cases of domestic violence that are reported directly to the prosecutor's office, the police department, and/or the hospitals. In addition to reports filed at the police departments and reports of arrests, the prosecutor's

office also kept records of all 911 calls made to Marquette police departments. Those cases that were substantiated are contained in the prosecutor's database. The prosecutor's database are also referred as *authorized cases*, meaning there is sufficient evidence of battering to proceed with a trial. It will need to be determined through analysis if these data registries will be considered as independent sources or will be combined into fewer sources. The data were collected within the same time frame from the various domestic violence prevention agencies within Marquette County - - 1995-1997.

XII. Limitations

One limitation of this research project is that persons that tend to get caught in these databases (enumerated) may be the more severe physical cases. For example, persons with less serious injuries will not seek treatment in the emergency rooms. There is no way to control for severity or intensity of injury; however, it is unlikely that there are women who were physically abused without being injured who presented at the hospital or shelter. While the capture-recapture technique lends itself well to controlling for dependencies, the severity of injury may not be controlled for without some form of injury measurement and thus, the data cannot control for injury.

XIII. Summation

This research uses the capture-recapture methodology that is currently being used in epidemiological studies for indirect estimation. This technique has never been utilized for indirectly estimating the proportion of the population experiencing intimate partner violence. Capture-recapture is a technique that is multi-methodological and is

appropriately used when there are multiple incomplete registries of a certain phenomenon. This research will first test the sensitivity of the formula by using a simulation study. Second, it will use three incomplete lists of victimized women: shelter, Outreach, criminal justice (including police, prosecutor and hospital). The lists are considered incomplete because the lists are not exhaustive based on the fact not all persons who are victims of intimate partner violence report their case, nor do these persons only report to a single agency. The lists of cases of women who are victims of intimate partner violence from at least three agencies will have identifiers which will allow the "linking" of cases from one database to the other. The links and nonlinks will be entered into the contingency tables as mentioned above to determine the missing cell. The ratio of linked cases to the second sample is estimated to be equal to the ratio of the first sample to the whole population. Point estimates will be calculated and followed up with tests for validity, reliability and controlled for necessary assumptions when appropriate.

In sum, capture-recapture provides a means to estimate the population of victims of physical abuse. While there are some precautions to be used for this technique in controlling for assumption violation, it is still a better means of estimation than using survey research or registries of cases of intimate partner violence as capture-recapture is better than any other existing enumeration measure (LaPorte, 1996). Characterizing the population of victims needs to be established and capture-recapture is the best available technique.

CHAPTER 3 – SIMULATIONS

I. Introduction

As a renewed interest in using capture-recapture methodology has arisen, so has concurrent polarization of the literature into believers and skeptics (Hay, 1997). One camp claims this provocative technique could be the cure-all to statistical, demographic, and epidemiological pitfalls in population estimation because it does not encumber the biases or costs of traditional techniques, such as surveys or registration systems (LaPorte, 1994; Watts et al., 1995; Shaw et al., 1996; Stephen, 1996). In contrast, there is growing concern from another camp with validity issues of capture-recapture methods (Hay, 1997). This dialectic was the impetus for developing controls for violations of 'necessary assumptions,' (Fienberg, 1998); however, the debate has since reached a stalemate (Hay, 1997). Even with improvements to the methodology, the accuracy of the capture-recapture is believed impossible to ascertain because it is used to estimate elusive and invisible populations, which are unknown in the first place (Hay, 1997). This chapter will shed some light on the capture-recapture controversy by illustrating the logistics of using capture-recapture, demonstrating the sensitivity of the model, and determining the precision of capture-recapture methods in predicting the size of an already known population.

This study overcomes research limitations by employing controlled experiments in the form of simulations. It allows the population to be preset and the prediction capabilities tested. In addition to testing the estimation power of the capture-recapture method, this research generates a "normal" capture-recapture distribution. In sum, this

research allows the capture-recapture dialectic to transcend some of the barriers and to move the discussion forward.

II. The Logistics of Capture-Recapture

Before demonstrating the precision and sensitivity of the capture-recapture model, it is necessary to understand the logistics of the model. Therefore, the following example will illustrate exactly how to employ this technique using three hypothetical data sources in a population of 1000 women. There are 26 cases of victims of domestic violence with fictitious names for demonstration purposes for three databases (see Table 3.1). One of these databases as a sole predictor of domestic violence (direct estimation procedure) would create an estimate of 26 per thousand cases. It is evident that single registries of a given phenomenon are missing other true cases and therefore, estimating incidence at the rate of 26 per thousand would be an underestimate. The more "hidden" the population is, the greater the underestimate becomes.

Similarly, the three databases cannot be simply added together to derive an estimate of incidence which would yield a rate of 78 per thousand (see Table 1). This is not correct because many of the cases are found in more than one registry.

Seemingly, the most logical way to derive an estimate of incidence would be to add the three databases together and to subtract out cases which have been counted more than once. This would yield a rate of 50 per thousand and is still a direct method of estimation. It is assumed that none of these databases contain all true cases in the population of interest, therefore, they are added together.

In this example as in real case registries, the three databases are not an exhaustive collection of domestic violence cases. Capture-recapture can be employed because it capitalizes on having more than one database and indirectly estimates the true population of cases by measuring the "overlap" between databases and not the joining of databases.

Using the formula for three factor capture recapture, we indirectly estimate the population by looking at the number of cases found in each database exclusive of the other databases, the number of cases found jointly in all three databases, and the number of cases found in a combination of two out of the three databases. Using Capture/Recapture we derive an estimate of 68 cases of domestic violence per 1000 persons. Following suit, we estimate the standard error (not based on probability) to be 8.8. This could be used to create a confidence interval of 58.8 to 76.4 cases of domestic violence.

In sum, counting entire populations and sampling are sometimes inappropriate research alternatives to estimating population size and even more so for hidden and elusive populations.

Table 3.1 Hypothetical Samples

Sample 1		Sample 2		Sample 3	
ID No.	Name	ID No.	Name	ID No.	Name
1	Mary Albert	1	Mary Albert	2	Christine Bosco
2	Christine Bosco	3	Beatrice Carrey	26	Thelma Xavier
3	Beatrice Carrey	7	Dalia Gallagher	24	Kiadra Zolton
4	Gertrude Dalton	8	Loren Hall	4	Gertrude Dalton
5	Abigale Evans	11	Wanda Kirk	9	Vivian Ithica
6	Shantelle Figaro	12	Noreen Lavender	13	Fergie Mason
7	Dalia Gallagher	15	Ophelia Oswald	17	Yolanda Queens
8	Loren Hall	16	Halle Pierson	18	Patricia Radcliffe
9	Vivian Ithica	21	Quintena Upstein	1	Mary Albert
10	Eva Juno	25	Megan Yeltzen	3	Beatrice Carrey
11	Wanda Kirk	27	Andrea Apple	7	Dalia Gallagher
12	Noreen Lavender	28	Barbara Busch	8	Loren Hall
13	Fergie Mason	29	Cherry Coldwater	11	Wanda Kirk
14	Xandria Nelson	30	Dorothy Dunn	27	Andrea Apple
15	Ophelia Oswald	31	Evelyn Edgar	28	Barbara Busch
16	Halle Pierson	32	Frani Fredrick	29	Cherry Coldwater
17	Yolanda Queens	33	Gail Getze	30	Dorothy Dunn
18	Patricia Radcliffe	34	Hedi Hopper	31	Evelyn Edgar
19	Indigo Sundry	35	Josephine Jaguar	43	Sheila Saber
20	Zena Tandy	36	Kyla Kola	44	Terri Treefold
21	Quintena Upstein	37	Luanna Larrow	45	Wilma Wallace
22	Justine Verigo	38	Margaret Mead	46	Ariel Arson
23	Ursula Watson	39	Natasha Nixon	47	Bethany Bardell
24	Kiadra Zolton	40	Orlanda Opal	48	Chloe Clemens
25	Megan Yeltzen	41	Paula Paddington	49	Diedra Dunson
26	Thelma Xavier	42	Rachel Ripzeld	50	Yvette Youth

III. Effects of Database Sensitivity to Model

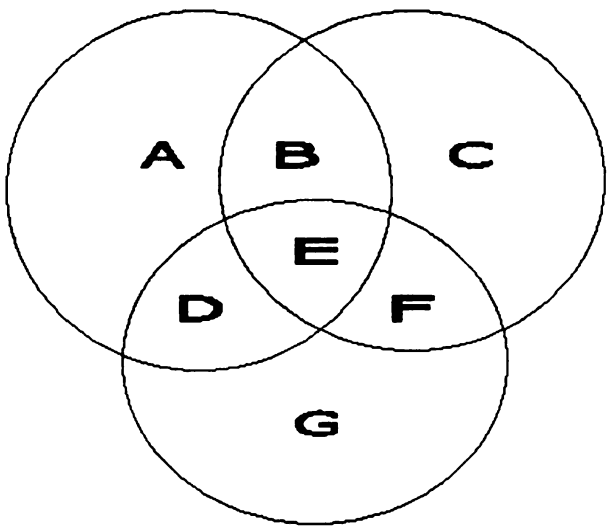
A simulation of the capture-recapture formula will demonstrate how sensitive the model is to the data. For trials 1 through 12, we set the total population at 1000. In this simulation, the uni-sample, bi-sample and tri-sample probabilities of being captured are varied to determine how sensitive the formula is to capture. In this example, the probability of being captured in sample one, two, or three is written as P1, P2, and P3

respectively. The probability of being captured in sample one (P1) is the probability one person out of a thousand is in section A, B, D, or E.

For trial 1: the probability of being captured in sample one is P = .33. The same is true for samples two and three (see Table 3.2). The probability of being captured in the intersection of samples one and two (see section B and E in Figure 3.2) given the person has already been captured in sample one or two is set at P12/1 and P12/2 = .30 respectively. The same probability is set for P23 and P13. Finally, the probability for being captured in all three databases (P123) given the person has already been captured in Samples 1 AND 2, Samples 1 AND 3, and Samples 1 AND 2 is set at .33. Given these uni-sample, bi-sample and tri-sample probabilities, the estimate of the total population[5] is 1242.

[5] This simulation is not intended to estimate realistic population sizes because dependencies have NOT been controlled, rather this exercise is a demonstration of the sensitivity of the model to dependencies.

Figure 3.1 Sections of Probability



For trials 2-4: The probabilities of the uni-sample and the tri-samples remain constant at P=.33 while the bi-sample probabilities are decreased by .5 per subsequent trial (See Table 3.2). With each decrease, the population estimate increases dramatically.

For trials 5-8: The uni-sample and the bi-sample probabilities are held constant at .33 and the tri-sample probability is decreased by .5 per subsequent trial. In contrast to trials 1-4, the decreasing probability has the opposite effect of decreasing the population estimates (See Table 3.2)

For Trials 9-12: The bi-sample and tri-sample probabilities are held constant at .33 and the uni-sample probabilities are decreased by .5 per subsequent trial. This decrease in probability also has a negative effect on the population estimates (see Table 3.2)

In sum, the model is sensitive to the probability of being captured. Also, the dramatic increases and decreases in the intersections of the three samples are indicative of the importance of matching cases. For example, if there is one case located in the intersection of samples one, two and three (Section E in Figure 3.1), and only two out of the three sources are matched, then it would have an incremental effect on the population estimate as opposed to a negative effect. This would lead to a decrease in the population estimate as we see in Table 3.2, the more like a person is to be captured in the two sample probability, the smaller the population estimate. An error such as this would have a double effect since the case would increase the bi-sample probability as well as decrease the tri-sample probability. The capture-recapture formula is more sensitive to errors for estimating populations than traditional survey research statistics.

Table 3.2 Probabilities of Being Captured

Trial	P_1	P_2	P_3	$P_{12/1}$	$P_{12/2}$	$P_{13/1}$	$P_{13/3}$	$P_{23/2}$	$P_{23/3}$	$P_{123/1}$	$P_{123/2}$	$P_{123/3}$	estimate
1	0.33	0.33	0.33	0.30	0.30	0.30	0.30	0.30	0.30	0.33	0.33	0.33	1242
2	0.33	0.33	0.33	0.25	0.25	0.25	0.25	0.25	0.25	0.33	0.33	0.33	1949
3	0.33	0.33	0.33	0.20	0.20	0.20	0.20	0.20	0.20	0.33	0.33	0.33	3564
4	0.33	0.33	0.33	0.15	0.15	0.15	0.15	0.15	0.15	0.33	0.33	0.33	7819
5	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.30	0.30	0.30	920
6	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.25	0.25	0.25	826
7	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.20	0.20	0.20	764
8	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.15	0.15	0.15	723
9	0.3	0.3	0.3	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	909
10	0.25	0.25	0.25	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	758
11	0.2	0.2	0.2	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	606
12	0.15	0.15	0.15	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	455

VI. Yes, but does it really work?

Given the logistics and sensitivity of capture-recapture, it is still not possible to determine the efficacy of the technique for indirectly estimating the population size. This

technique is used when the true size of the population is unknown, therefore, ascertaining the accuracy is difficult. As discussed in the reliability and validity discussions in the research methods chapter of this dissertation, there are significant benefits of having multiple samples from which to estimate the same population as is the case in capture-recapture. However, there are other means to determine precision.

A. Empirical Reality

There is significant evidence in previous research studies that capture-recapture netted good estimates of invisible populations. For example, public health workers in Bangkok suspected much higher rates of heroin use than were detected in survey data and registries. Higher rates were suspected because public health researchers were able to determine the percentage of heroin users who were HIV positive. The number of HIV cases increased more than the reported number of heroin users. In an epidemiological study using capture-recapture Mastro et al. (1994) estimated the number of injection drug users in Bangkok. Mastro et al. (1994) was able to count those cases missed by direct estimation procedures. An additional six thousand heroin users were identified which directly reflected the increase in HIV cases that were known to be contracted from heroin usage.

B. Other Applications

Animal scientists[6] have long since monitored animal and insect species using capture-recapture. With this technique wildlife specialists have learned how many

[6] The US Fish and Wildlife Services, the National Wildlife Federation, and the Biological Resources Division of the US Geological Survey

animals within a species exist, sex ratios, location, migratory patterns, frequency of breeding, habitat ecology, survival rates and fertility rates. The information these scientists collect regarding animal species is so intrinsically specific that several species on the verge of extinction have been rescued due to the tailored "Recover Programs". "*Animal demographers*" understand the fertility, mortality, migration processes and population size of some elusive creatures (Boukhout, 1994; Schemnitz, 1980, Seber, 1993).

C. The Precision of the Capture-Recapture technique

In reality we can never determine if a capture-recapture population estimate is accurate, but in theory we can. A simulation can elucidate the precision with which capture-recapture is able to estimate the population.

In the following example, a two-factor model of capture-recapture is used to predict a preset population of 1000 and 2000. A hundred trials were calculated for each level of probability at the given preset population size. The simulation calculated estimates of the population according to each probability of capture. The average estimate and standard deviation of the 100 trials are listed in Table 3.3. As the probability of being captured increases, the mean estimate is closer to the real population and the smaller the standard deviation becomes. This simulation was only calculated for two factor models as there are no dependencies. The three factor model can only accommodate specific dependencies between samples and therefore, an estimate for comparison is not possible without log-linear modeling.

When the number of cases captured in the samples drops below 15%, the standard deviation becomes quite large. As the probability increases for capture, the smaller the standard deviation becomes. The inverse relationship between probability of capture and standard deviation is consistent regardless of sample size. However, since standard deviation is a function of sample size the statistic "Coefficient of Variability" is also calculated. The Coefficient of Variability takes into account the fact that distributions with very large means usually have larger standard deviations by dividing the standard deviation by the mean (Blalock, 1960). In the final column of Table 3.3, the Coefficient dramatically decreases when the probability of capture is less than .15.

Table 3.3 Measure of Precision

Sample Size	Probability of Capture[7]	Mean Estimate	Maximum Estimate	Minimum Estimate	Standard Deviation	Coefficient of Variability
1000	.05	1298	3105	302	721	.56
1000	.10	1124	2179	602	294	.26
1000	.15	1029	1527	656	192	.18
1000	.20	1027	1349	791	124	.12
1000	.25	1025	1386	889	88	.08
1000	.30	1012	1262	891	77	.07
2000	.05	2524	10494	993	1489	.58
2000	.10	2056	3534	1259	458	.22
2000	.15	2046	3071	1577	269	.13
2000	.20	2024	2817	1648	199	.09
2000	.25	1996	2451	1658	137	.07
2000	.30	1992	2263	1767	98	.05

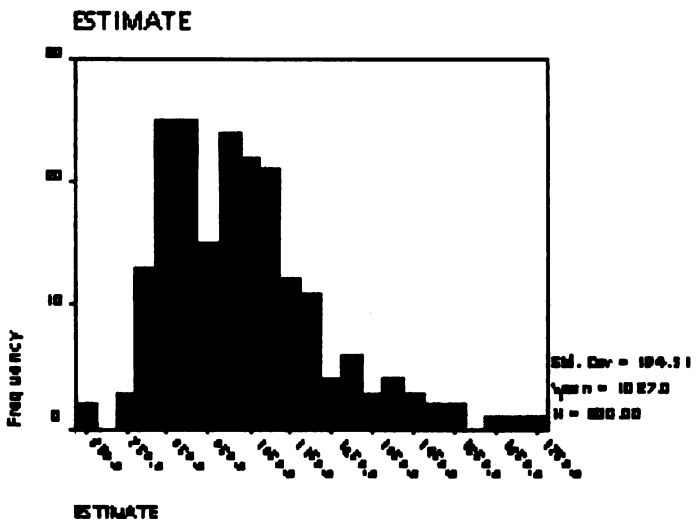
D. Distribution of Capture-Recapture Estimates

In another type of simulation, a typical distribution of capture-recapture estimates is created. Using a simulation program to randomly generate capture-recapture estimates,

[7] Probability is $P_{12/1}$ and $P_{12/2}$

two-hundred trials were executed. The two-factor capture-recapture model generated a mean score of 1036 with bi-sample probabilities P12/1 and P12/2 of .15. These estimates create a distribution that is skewed to the right. The skew of the capture-recapture distribution is 1.09 as shown in Figure 3.2.

Figure 3.2 Distribution of Capture-Recapture Estimates



V. Conclusions

In response to the first research question, *can the capture-recapture technique indirectly estimate the size of an invisible population,* capture-recapture is a useful statistical technique to estimate the size of invisible populations; however, there are some cautionary measures to be implemented during application. This technique must be employed with strict scientific rigor by utilizing methodologies to control for violations of the necessary assumptions. These simulations have demonstrated that the model is indeed sensitive and therefore, it would not suffice to just give point estimates as opposed

to confidence intervals. This simulation has defined some parameters for estimating the population. As shown in Table 3.3, when sample representation drops below 15%, the confidence placed in the estimate is reduced considerably as the standard deviation doubles. When sample representation of the observed cases exceeds 15%, the standard deviation decreases substantially and the range of estimates decreases. The smaller the probability of being captured in the sample, the less confidence the researcher should hold in the point estimate and rely more heavily on the confidence intervals constructed around the point estimate.

The capture-recapture estimates indicate a positively skewed distribution. This distribution should be considered when calculating standard errors for use in confidence intervals. The upper parameters should have more credence than the lower parameters because of the positive skew. This study supports Fienberg's (1998) contention that it is best to profile population estimates with intervals to reduce the errors and the interval between the point estimate and the upper parameter are more likely to contain the true population than the lower parameter.

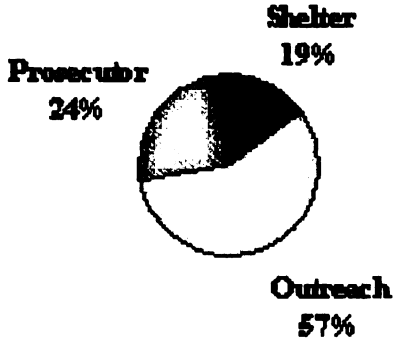
In sum, capture-recapture can be a powerful technique in population enumeration as long as the researcher has an overall understanding of model sensitivity and point estimates.

CHAPTER 4 – CAPTURE-RECAPTURE

I. Subject and Database Descriptions

The data to be used for these analyses come from multiple sources in Marquette County between January 1995 and July 1997. There are three analytic sources which "is a list which may be constructed from one or more original sources" (Hook and Regal 1995, p. 244). The three sources are: 1. Prosecutor's database; 2. Domestic Violence Shelter files; 3. Outreach Services files (see figure 4.1[8]). The original sources, "a particular list of cases from some institution" (Hook and Regal 1995, p. 244) have been collapsed into the analytic sources.

Figure 4.1 Analytic Sources for Capture-Recapture



[8] Cases from each agency list may also be represented in one or both of the other agencies as duplicated cases are not subtracted out.

Both estimations of incidence and prevalence will be calculated based on these data. Incidence is the total number of physical *assaults* by an intimate partner within the given time frame. Whereas, prevalence is the number of *victims* physically assaulted by an intimate partner within the give time frame. Some victims may have experienced multiple incidents of physical violence, however, prevalence is an indicator of the proportion of the population affected as opposed to the frequency.

Cases of intimate partner violence enter the prosecutor's database via the medical system and the policing agencies or independent complainants of Marquette County. According to Michigan Law, policing agencies must formally report all calls, reports, or investigations to the prosecutor's office within two days, also known as the 48-hour report.[9] Not all persons in the prosecutor's database have been arrested but all cases have been *authorized* to go to trial based on evidence. Suspects are frequently prosecuted without having been arrested in cases of intimate partner violence. Hershel and Hutchinson (1993) reported that in more than 50% of the cases of intimate partner violence, an arrest is not made because the suspect is not present when the officer arrives. Maxwell (1998) stated in these cases, the perpetrator can be arraigned without ever having been arrested. The Marquette prosecutor's office receives cases of intimate partner violence from the following police agencies:

- Forsyth Township Police Department
- Republic Township Police Department

[9] X. SB 587 - P.A. 63 OF 1994. Effective 7-1-94.
Amends the Code of Criminal Procedure to require police officers to make a written report, including standard basic information, in response to all domestic violence calls, requires that such reports are submitted to the prosecutors office for review. Also revises the domestic violence victims rights notice to include information about the police response and clearer direction toward victim rights and referrals. Repeals the statue that formerly required the court to dismiss a case without prosecutor's consent if the victim stated s/he had received civil satisfaction.

- Marquette County Sheriff's Department
- Ishpeming Township Police Department
- Negaunee Police Department
- Richmond Township Police Department
- Northern Michigan University Public Safety
- Marquette Police Department
- Michigan State Police
- Ishpeming Police Department
- Chocolay Township Police Department

Medical personnel are also required to report[10] all persons presenting at their agency with injuries sustained from intimate partner altercations to the appropriate police department. In turn, those cases are forwarded by the police department to the prosecutor's office in the 48-hour report. The two hospitals in Marquette County are Marquette General and Bell Memorial in the towns of Marquette and Ishpeming respectively. Both these hospitals reside in Marquette County.

All cases of male on male (22) and female on female (23) assaults were removed from the prosecutor's database because the other data sources did not contain same sex assaults during the research time period and therefore, analysis was not possible without overlapping cases. Male-on-female and female-on-male violence were analyzed separately.

[10] It is the duty of every person or corporation conducting or managing any hospital, pharmacy, or ward in this state, to which any person(s) suffering from any wound or other injury inflicted by means of a knife, gun, pistol or other deadly weapon, or by other means of violence shall come, to report the same immediately. The report should be both by telephone and in writing to the Chief of Police or Sheriff of the village, city or county in which the hospital or pharmacy is located. The report must state the name and the residence of the person, if known, his whereabouts, and the character and extent of the injuries. It is also the duty of every physician or surgeon who has any person suffering from any wound or injury inflicted in the manner above mentioned under his care to make a similar report to the appropriate officers named above. Any person, firm or corporation violating any provision of the section is guilty of a misdemeanor. MCLA 750.411.

II. Male-on-Female Intimate Partner Violence

The prosecutor's database contained 184 females during this two and half year study. The number of incidents (198) was greater than the number of victims as some victims experience multiple attacks from their perpetrator and thus, a victim may have more than one case referred to the prosecutor's office.

There are two Outreach Offices run by the Women's Center Inc. of Marquette County. Their services are similar to the programs found in the shelter, however, they differ in that they are for women who are not in need of shelter. Outreach services include crisis counseling and support, housing assistance, childcare, legal advocacy, and transportation to legal assistance. There were 280 women using the Outreach services during the two and a half-year study period. These women reported 472 incidents of domestic violence to either the Ishpeming office or the Marquette office.

Finally, Harbor House is the sole domestic violence shelter for victims of intimate partner violence in Marquette County. There were 136 women seeking shelter on 155 occasions within the two and a half-year study period. This agency also provided shelter for their children. Children are recognized victims of intimate partner violence as they are traumatized by their mother's abuse in addition to the fact that batterers are 45-59% more likely to be child abusers (Jones, 1994; Edleson and Tolman, 1992). However, for purposes of this study, children are excluded from analysis. The shelter performs many of the same services as the Outreach office except they also offer safe accommodations for women and children in hiding from their perpetrator.

III. Necessary Assumptions

There are four assumptions that must be met in order to utilize the capture-recapture technique as described by Nanan and White, (1997) Hook and Regal, (1995) and Fienberg, (1998).

A. Closure

The population under study is closed. The population of Marquette County remains stable in demographic terms during the two and a half-year period. One consideration is the number of IPV related homicides where the victim is no longer "at risk" for assaults. There were two domestic homicides during the period of study. This mortality will not have an effect on the prevalence rate, but it may have affected the incidence rate although the number is so small it would have had negligible effects on the estimations.

Closure of population is more crucial in animal ecology studies where the samples are taken sequentially. In the case of this research, data were being recorded simultaneously in all sources. This is less problematic because even if a victim moved out of the area, she still had the potential to be captured in the three sources during her tenure. Finally, closure of population is a form of dependency and can be controlled for as is discussed further down.

B. Perfect matching

Individuals identified in one source are perfectly matched in another without error with no mismatches or non-matches. There is a lower risk of matching error, as the

investigator is extremely familiar with the population and the victims. Furthermore, a single investigator read and entered the data into the databases for both the outreach and the shelter. In addition, there were several case 'identifiers' such as victim first name, last name, middle name, maiden name, age, birthdate, race, address, perpetrator last name, first name, date of incident. The prosecutor's database also recorded the outcome of the case, which provided further information for identifying cases. The shelters and outreach offices both maintained records on victims and their outcomes, changes of names, birth of children, moves, etc. Therefore, it was possible to check matches by misspelled names, naming variations, nicknames, and changed names.

Data were also sorted by perpetrator and victim birthdates, to further check for potential matches. The victim's date of birth was requested in both the prosecutor and shelter sources, whereas, the Outreach offices used self-reported "age" of victim. There appeared to be some discrepancy between age generated from the "date of incident" minus the "date of birth" and the self reported age for some women over the age of forty. After careful rechecking of the records from the original source, it was concluded that some women presenting in the Outreach office were misreporting their age. Occasionally, a respondent would misreport her age and in those cases, the older the respondent, the greater number of years would be subtracted from actual age. Subtracting years was only found in women age of forty-three and older. The age of victim was missing in 52 of the cases, however, there were enough other identifiers to determine positive matches. The cases were matched on several fields creating confidence in the matching. The age generated from the prosecutor source was extended to the reported age of the respondent

in the event of a discrepancy because prosecutor date of birth was obtained from official records such as a driver's license.

C. Independence

The independence assumption is that the probability of being in one list is not affected by the probability of being on another. This assumption is violated in the case of intimate partner violence for Marquette County. As communities strive to combat intimate partner violence, agencies are collaborating more with each other in an attempt to have a coordinated response to domestic violence. Women presenting in shelters and outreach offices are encouraged to have their injuries treated by medical personnel and report their cases to the police. Similarly, police officers that respond to a domestic are mandated to provide the victim with information on the shelter and outreach office. Furthermore, there is a community council in Marquette County created to implement a coordinated agency response and to improve services for victims. All Marquette hospitals, police agencies, women's services, and prosecutors are active participants in the council. There are several domestic violence projects located in Marquette County that improve the services and increase communications between the agencies. Two of the major projects are 'The Justice Project' implemented by the prosecutor's office and funded by the National Institute of Justice and the Marquette Research for Justice and Violence Agencies (MR JAVA) funded by the Michigan Department of Community Health. In addition, there are several other smaller domestic violence projects which are funded by the Family Independence Agency and Victims Compensation Board that contribute to dependencies of data sources.

Dependencies can be thought of as both positive and negative and both can be present within the same model. In the case of Marquette County, while we expect there to be a positive relationship between the shelter/outreach and the hospital or the shelter/outreach and the police department, we also expect there to be a negative relationship between the police department and the shelter. The rationale for this assumption is based on the logic that with improved police response there is a decreased need for shelter. If the perpetrator is removed by arrest and jail time, a woman is not in need of hiding. Similarly, the Outreach Programs and the shelter provide many of the same services except Outreach does not provide shelter. Therefore, if a victim uses the services of a shelter, she will not need Outreach Services. However, if a woman is frequenting an Outreach office and her safety becomes compromised, she will be referred to the shelter. Many women in shelter are not trusting of the criminal justice system and do not want to report to the police department for fear of an increased retaliation by the perpetrator and perception the legal process will prolong the connection of the perpetrator to the victim (Personal communication with shelter director May 1998).

In sum, there are several theoretical positive and negative dependencies in this research model. It would appear these data should support a model with two-way interactions between all the sources. Fienberg (1972) made considerable contributions to the capture-recapture estimation technique with his use of log-linear modeling to control for sample dependency, which will be employed in this research and discussed later in this chapter. Capture-Recapture estimates are based on Maximum Likelihood Estimates of parameters of log-linear modeling (Haberman, 1974). Proofs of these estimates are

based on the existence and uniqueness of Maximum Likelihood Estimates in exponential family distributions (Andersen, 1974).

D. Homogeneity

The final assumption to be met is homogeneity (also known as catchability) - whereby all subjects must have an equal probability of being captured. The degree of homogeneity can bias the results by both overestimating and underestimating the population (Hook and Regal, 1995; Nanan and White, 1997). Variable catchability is also a form of source dependency that can be reduced through log-linear models. In addition, this assumption can be met by stratifying the sample according to certain characteristics to look for differential estimations. An indicator of variable catchability is to explore if any population characteristics differ between the different sources. One data source may be more sensitive to a certain characteristic and therefore, may be more likely to catch a person based on a particular characteristic. An analysis of socio-demographic characteristics revealed that 79.2% of the sources were White, 3.5% were Black, 3.5% were Asian, 11.7% were American Indian, 1.7% were Hispanic, and .4% were mixed descendent. The racial distribution of the general population of Marquette County is Black 1.7%, American Indian 1.3%, Asian .8%, and Hispanic .8%. There was slight over representation of Blacks in the three data sources and underrepresentation of Hispanics. There was an extreme overrepresentation of Asians in the three data sources. A chi square test of race and data source netted a value of 5.39 with $p < .864$ indicating there was no significant difference between race and source of data. However, there are still differences between victims and the general population.

The average age for the combined sources was 33.1 years with a standard deviation of 10.8. The average age of clients in the Shelter data was 35.6 years, 34.3 years for the Outreach source and 30.0 years for the Prosecutor source. A one-way ANOVA resulted in an F value of 12.98 with a $p < .000$ indicating there was variability of age between datasources and there was a significant difference between the average ages of each data source. The median age for the general population of Marquette County is 30.7 years. This test should be considered cautiously as it is not an absolute that the varying characteristics between sources are indicative of variable catchability, only that the average age is significantly different between data sources. However, as hypothesized in this research, there is indication younger women are more likely to be found in institutional data than older women and therefore, more likely to be caught in any one data source.

Each institutional database provides a separate snapshot of domestic violence. This amounts to three pictures from different perspectives of a single phenomenon. Individually, a single source can give a unique perspective of the situation but is not able to stand alone as an indicator of IPV. Analogously, these three sources are finding the same racial composition among the three institutional sources, however, they are not finding the same age composition which MAY indicate there are characteristics of the institution itself that lends itself to "catching" a specific age group more easily. These data will be tested for varying catchability by stratifying older and younger aged women into independent estimates of IPV. These data will be stratified after identifying the best fitting model.

IV. Maximum Likelihood Estimator (MLE)

After subtracting out the duplication between the three data sources, there are 520 women and 825 incidents of intimate partner violence in this study. The overlap of the incidence and prevalence studies is demonstrated in figures 4.2 and 4.3 respectively.

Figure 4.2 Overlap of Incidence Data Sources

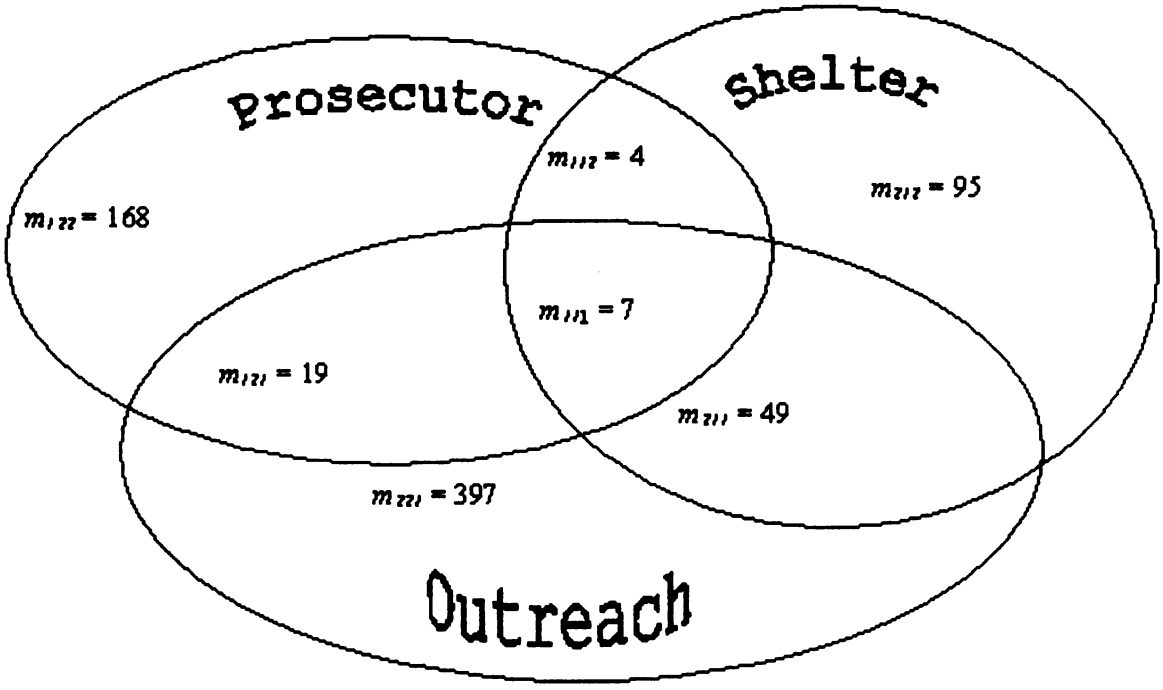
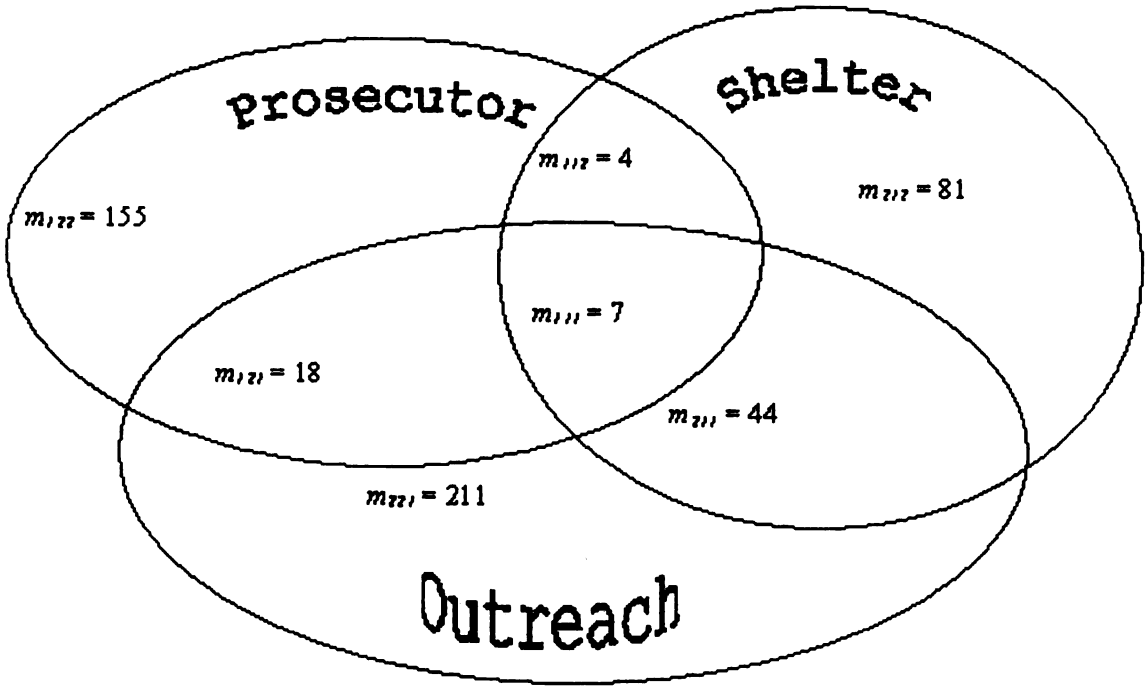


Figure 4.3 Overlap of Prevalence Data Sources



The three data sources are divided into sections of overlapping cases and non-overlapping cases (Table 4.1).

Table 4.1 Sections and Intersections of 3 Sources

N_{obs} = Observed cases	$m_{111} + m_{112} + m_{122} + m_{211} + m_{221} + m_{212} + m_{121}$
N_1 = Prosecutor Source	$m_{111} + m_{112} + m_{122} + m_{121}$
N_2 = Shelter Source	$m_{111} + m_{112} + m_{211} + m_{212}$
N_3 = Outreach Source	$m_{111} + m_{211} + m_{221} + m_{121}$
N = Total Population	$m_{222} + N_{obs}$
m_{222} = Invisible Population	See Maximum Likelihood Estimator's Below

Databases with known "intersections" lend themselves well to capture-recapture to estimate the invisible population and multiple sources lend themselves well to log-linear

modeling (Fienberg, 1972). Using the traditional Peterson estimation (1896) or Lincoln index (1930) we assume our samples are independent for two-source capture-recapture. Under the condition of independence (taken from Fienberg, 1972) we know that:

$$\frac{m_{11}m_{12}}{m_{12}m_{21}} = 1$$

The cross-product ratio for the expected entries in the 2 X 2 table is unity. Thus, the maximum likelihood estimate of m_{22} allows us to estimate the missing cell by:

$$\frac{m_{12}m_{21}}{m_{11}} = m_{22}$$

Therefore, to estimate the total population N, the missing cell, m_{22} is estimated by the cross-product ratio and added to the observed population, N_{obj}, which is calculated by:

$$N_{obs} = m_{12} + m_{21} + m_{11}$$

Therefore:

$$N = \frac{m_{12}m_{21}}{m_{11}} + (m_{12} + m_{21} + m_{11})$$

V. Log-linear Modeling to Control for Sample Dependency

By fitting three or more data sources to contingency tables as in Figure 4.4, we can estimate N.

Figure 4.4 Contingency Table for Three Sources

		PROSECUTOR			
		present		absent	
		SHELTER		SHELTER	
		present	absent	present	absent
OUTREACH	present	m_{111}	m_{121}	m_{211}	m_{221}
	absent	m_{112}	m_{112}	m_{212}	m_{222}

The odds ratio is set for level one of source 1 equal to that for level two (Fienberg, 1998).

$$\frac{m_{111}m_{221}}{m_{121}m_{211}} = \frac{m_{112}m_{222}}{m_{122}m_{212}}$$

We solve to estimate m_{222}:

$$m_{222} = \frac{m_{111}m_{122}m_{212}m_{221}}{m_{112}m_{121}m_{211}}$$

And thus can estimate:

$$N = N_{obs} + m_{222}$$

Where the observed population is:

$$N_{obs} = m_{111} + m_{221} + m_{121} + m_{211} + m_{122} + m_{212} + m_{112}$$

As in the case of this study, three data sources will be used to estimate the invisible population. There are eight potential models that may fit the data derived from three sources based on the interdependencies (Hook and Regal, 1995). "As with independence in 2-way case, we can't test for appropriateness of no 2nd-order interaction assumption, but we can fit other log-linear models to the data" (Fienberg, 1998). To test for 2nd order interactions, there must be four or more sources of data.

Where:

$$\log m_{ijk} = u + u_{1(i)} + u_{2(j)} + u_{3(k)} + u_{12(ij)} + u_{13(ik)} + u_{23(jk)}$$

Where:

u = The Constant
$u_{1(i)}$ = The Main Effect of Source 1 (prosecutor data)
$u_{2(j)}$ = The Main Effect of Source 2 (shelter data)
$u_{3(k)}$ = The Main Effect of Source 3 (outreach data)
$u_{12(ij)}$ = The Interaction Effect of Source 1 and 2
$u_{13(ik)}$ = The Interaction Effect of Source 1 and 3
$u_{23(jk)}$ = The Interaction Effect of Source 2 and 3

The following eight models are listed by Hook and Regal (1995) as the potential models for three-source capture-recapture log linear control.

Table 4.2 Interactions According to Model

Interactions	Model	degrees of freedom
Independence	1	3
Interactions between databases 1 and 2	2	2
Interactions between databases 1 and 3	3	2
Interactions between databases 2 and 3	4	2
Interactions between databases 1 and 2 and databases 1 and 3	5	1
Interactions between databases 1 and 2 and databases 2 and 3	6	1
Interactions between databases 2 and 3 and databases 1 and 3	7	1
Interactions between databases 1 and 2 and databases 1 and 3 and databases 2 and 3 (saturated model)	8	0

The corresponding Maximum likelihood estimates (see below) of m_{222} using the alternative models to control for sample dependency are as follows (see figure 4.4 for cell labels):

- Model 1: $m_{222} = N - N_{obs}$
- Model 2: $m_{222} = (m_{112} + m_{122} + m_{212})(m_{221})/(m_{111} + m_{121} + m_{211})$
- Model 3: $m_{222} = (m_{112} + m_{122} + m_{221})(m_{212})/(m_{111} + m_{112} + m_{211})$
- Model 4: $m_{222} = (m_{211} + m_{221} + m_{212})(m_{122})/(m_{111} + m_{121} + m_{112})$
- Model 5: $m_{222} = (m_{212}m_{221})/ m_{211}$
- Model 6: $m_{222} = (m_{212}m_{122})/m_{112}$
- Model 7: $m_{222} = (m_{122}m_{221})/m_{121}$
- Model 8: $m_{222} = (m_{111}\, m_{122}\, m_{221}\, m_{212})/(\, m_{121}m_{112}\, m_{211})$

VI. Establishing Incidence and Prevalence

For these analyses the three data sources were fitted to each of the eight models to derive an estimate for the missing cell m_{222}. Their corresponding Maximum Likelihood Estimates (MLE) are listed below in Table 4.3 for both prevalence and incidence. Prevalence refers to the number of battered women and incidence refers to the number of incidents of intimate partner violence.

Table 4.3 Incidence and Prevalence MLE by Model

Model	Incidence MLE	Incidence G^2	Prevalence MLE	Prevalence G^2
2	1,413	257.9 *	734	173.6 *
3	901	226.0 *	545	157.4 *
4	3,030	58.5 *	1,796	28.2 *
5	770	205.6 *	388	148.2 *
6	3,990	38.1 *	3,139	19.0 *
7	3,510	6.2 °	1,817	2.8
8	11,910	1.0	5,853	.008

* $p < .000$
° $p < .05$

In addition to using three sources in the log linear models, there are three additional models whereby, one of the data sources is dropped for a two-source restricted model (Hook and Regal, 1995). The Maximum Likelihood Estimates are as follows in Table 4.4 for both incidence and prevalence for comparative purposes.

Table 4.4 Two-source Restricted Models for Three Data Sources

Model	Formula	Incidence	Prevalence
Source 1 verses 2 (Prosecutor and Shelter)	$(N_1)(N_2)/(m_{111} + m_{112})$	2,790	2,275
Source 1 verses 3 (Prosecutor and Outreach)	$(N_1)(N_3)/(m_{111} + m_{121})$	3,594	2,061
Source 2 verses 3 (Shelter and Outreach)	$(N_2)(N_3)/(m_{111} + m_{211})$	1,306	747

The wide range of estimates is indicative of both negative and positive dependencies in the data sources (Hook and Regal, 1995) as was suspected in this case. This indicates there is no three way positive or negative dependency in this model. A

three-way positive dependency would mean that being present in one data source would increase the likelihood of a person presenting in both the other two data sources. Similarly, a three-way negative dependency would mean that being present in one data source reduces the likelihood a person appears in the other two data sources. Unmodeled positive dependencies tend to underestimate the size of total population and unmodeled negative dependence tends to overestimate size of total population (Hook and Regal, 1995). Now that multiple models were used to estimate the MLE, we must determine which model is the "best fit" for the data. Theoretically, we begin with the simple models devoid of dependencies and add in parameters until the model is saturated. Due to the cross-over of agency referrals, we expect there to be dependencies between data sources. The dependencies are shown ranging from a single two source dependency (model 2) to a model (8) where all two sample interactions are controlled. Theoretically, the simple models do not fit the data because of the known dependencies. Further tests of statistical significance of these models determine the simplest model with sufficient parameters to fit the data. Using SPSS, these data were analyzed by selecting the saturated model and using the process of backward elimination to test the various models. The Iterative Proportional Fit algorithm converged at iteration 1, meaning the saturated model is the best fit for the incidence data. There was nothing significantly added to the model by dropping any of the parameters. The likelihood-ratio goodness-of-fit statistic (G^2)[11] for the saturated model equals 0 and is insignificant. The likelihood-ratio goodness-of-fit statistic (Demaris, 1992) is calculated by:

[11] The model which generates the lowest G^2 value while being insignificant is the model with the best fit.

$$G^2 = 2\sum n_{ij} \log \frac{n_{ij}}{m_{ij}}$$

Therefore, the log-linear model:

$$\log m_{ijk} = u + u_{1(i)} + u_{2(j)} + u_{3(k)} + u_{12(ij)} + u_{13(ik)} + u_{23(jk)}$$

is the best fitting model for the incidence data and therefore, we accept the estimate derived with model 8 (see Table 4.2) as our estimate for incidents of intimate partner violence in Marquette County. Thus by knowing m_{222} = 11,910, we can solve for N, the predicted population, by adding the missing cell to the observed population. Hence,

N = 11,910 + 739 = 12,649

In sum, based on these data there were an estimated 12,649 incidents of intimate partner violence in Marquette County between January 1995 and July 1997. However, due to the difficulty in defining an incident[12] and problems with clustering, the incidence values are not expected to be accurate as the prevalence estimates.

The prevalence data were also tested using log-linear modeling to determine which model is the best fit. The model selected by the backward elimination process as the best fit was model 7 (See Table 4.2), which dropped the parameter of the interaction between the prosecutor and the shelter sources. The likelihood ratio for model seven was 2.8 and was significant at $p < .246$. Model seven is the most simple while being insignificant and therefore, is accepted as the best fit. Therefore, this log-linear model

[12] Some women reported beatings that lasted for extended periods of time with intervals of rest for their assailant or multiple beatings within a single day. Furthermore, it was impossible to determine which arrests correlated with a specific incidence since they may have occurred on different days. Prevalence estimates are not problematic as they only require matching the victim between samples.

best describes the data in a simpler model with one less parameter by setting this parameter, $u_{12(ik)}$, equal to zero:

$$\log m_{ijk} = u + u_{1(i)} + u_{2(j)} + u_{3(k)} + u_{12(ij)} + u_{13(ik)} + u_{23(jk)}$$

We know that the estimate generated by model seven is 1,817. Therefore, adding the observed cases to the unobserved cases we can solve for N.

$$N = 520 + 1,817 = 2337$$

Based on these data there were an estimated 2,337 women in Marquette County between January 1995 and July 1997 who experienced one or more assaults by an intimate partner.

VII. Stratifying the Data

The data are stratified according to age group: Those women less than forty years of age at the time of their assault and those women aged forty years and older. The division of age into two groups is based on the assumption that most women have completed fertility by their 40th year. Using the best model for the prevalence estimations, the following estimations in Table 4.5 are generated according to age group.

Table 4.5 Prevalence Estimations Stratified by Age

Data[13]	Total Population[14]	Women < 40	Women 40 +
m_{111}	7	5	2
m_{122}	153	127	26
m_{121}	16	13	3
m_{112}	4	4	0
m_{211}	39	24	15
m_{212}	85	56	29
m_{221}	116	82	34
m_{222}	1109[15]	801	295
N_1	180	149	31
N_2	135	89	46
N_3	178	124	54
N_{obs}	420	311	109

These sections and intersections were used to estimate the prevalence according to age-group in Table 4.6 using the best fit model (model #7) as stated above.

Table 4.6 Prevalence Estimates According to Age

Age-group	$(m_{122}m_{221})/m_{121}$	m_{222}	N_{obs}	N_{tot}	C/R Ascertainment
Total	153 x 116 / 16	1109	420	1529	.37
Women < 40	127 x 82 / 13	801	311	1112	.38
Women 40 & >	26 x 34 / 3	295	109	440	.37

As found in Table 4.6, the data sources are divided into younger and older age groups. However, the unstratified data fall short of the independent estimations sources by 23 cases, meaning the sum of the prevalence population estimates (N) for younger and older women (1112 and 440 respectively) is greater (1552) than the prevalence population estimate in the unstratified model (1529). We would expect a different pattern

[13] See Figures 4.3 and 4.4 for notation explanation of Table 4.5.

[14] These estimates include those for both age groups. However, these estimates will deviate from the total population estimates stated above because there were 107 cases used in the previous estimations that did not include age of victim and therefore, those cases are deleted from the age-stratified estimations.

of estimates if there existed varying catchability according to age. Since the sum of the Maximum Likelihood Estimates of the stratified samples approximates the unstratified sample, it would appear that there is not variable catchability. One of the age groups should predict a much higher estimate or a much lower estimate if there were sufficient variability. Therefore, the age effects on catchability do not create under and over estimates. This is consistent with the findings of Gondolf, Chang, and Laporte (1997) of a batterer's program where they used reports by victims, police, and perpetrators to estimate the incidence of re-assault after perpetrators of domestic violence were made to attend a batterer's prevention program. Gondolf et al. (1997) did not find varying catchability due to demographic characteristics and relationship to perpetrator. However, there appeared to be some bias in the sampling by catching the more severe cases of assault, as is expected in this analysis[16]. Those persons presenting in emergency rooms, police departments, and shelters are generally going to be the more severe cases that result in injuries. Using the unstratified model is sufficient for this study, however, it will net a conservative estimate as this study focuses on the physical assaults that lead to injury.

In the Capture-Recapture Ascertainment Column of Table 4.6 there is evidence that this estimation technique varies slightly by estimating the prevalence according to age group. This is evident from dividing the observed population of the three data sources by the predicted population prevalence. We find that 37% of the predicted population is explained by the observed population for both the unstratified model and the stratified

[15] This estimate is NOT a sum of the two age subgroups, but rather an independent estimation based on cell counts.

[16]This does not necessarily indicate that the estimate will exclude the less severe cases of violence because those cases can be included in the invisible cell.

model for the older age-group while the younger age-group's observed population explains 38% of the predicted population estimate. Meaning, there were slightly more observed cases used to predict the invisible cases for older women than younger women. In sum, it would appear that older women are indeed an invisible population, however, not more invisible than younger women.

VIII. Calculating Standard Error for Capture-Recapture Models

The standard error can be used to create a type of confidence interval; however, since it is not a true interval based on probability, it can create an incorrect lower limit which is a false-positive, therefore, an interval should not be used or used with caution. There is a better technique based on goodness of fit to determine whether a point estimate is appropriate (Hook et al., 1995).

For a saturated model that assumes all two-way interactions between sources and no second order interaction for a three source model, the asymptotic variance "for this estimate for N is intimately related to the asymptotic variance of a log-linear contrast" (Fienberg, 1998). The asymptotic variance is written as:

$$V(N) = m_{222}^2 \left(\sum \frac{1}{m_{i,j,k,}} + \frac{1}{m_{222}} \right)$$

It can be problematic to use the asymptotic variance of a saturated model as often the interval length will have a lower estimate than the actual observed cases. This is especially the case when the sample size is not that large (Hook and Regal, 1995). Fortunately, the prevalence data fit Model number 7 (see table 4.2) and therefore, the

asymptotic variance can be calculated by using the expected frequencies instead of the observed frequencies. Therefore, the asymptotic variance derived from the log-linear model specified by setting exactly one 2-factor term equal to zero (taken from Fienberg, 1972) $u_{12(ik)}$, = 0,

$$V(N) = m_{222}^2 \left(\frac{1}{m_{122}} + \frac{1}{m_{212}} + \frac{1}{m_{112}} + \frac{1}{m_{222}}\right)$$

In a larger sample, the standard error would be small enough to create a meaningful confidence interval, however, in this case, the sample size is too small.

IX. Point Estimates for Capture-Recapture

As seen in Table 4.7 below, many of the estimates fall within a close range. There are some point estimates generated by some models that fall too low because the model has not controlled for a specific dependency. For example, when looking at the data intersections in figure 4.3, we can see that the largest dependency is between the shelter data and the outreach data (sources 2 and 3). Therefore, we expect an estimation that does not control for this dependency to completely underestimate the population size. Hence, in the two source model for sources 2 vs. 3 generates a point estimate below the best model point estimate because the model does not incorporate dependencies between those two data sources. Another example of a gross undercount is in the case of model five that controls for all two-way interactions minus the interaction between source 2 and source 3. Analogously, model three is a good estimator since it does incorporate the dependencies between sources two and three. Model 7 is a better estimator because it also

adds in the effect between the prosecutor's data and the outreach data and makes an additional correction for the dependency between source 1 and 3. In sum, these range of estimates validate our best model Maximum Likelihood Estimate because they land theoretically, where they should. When using the asymptotic variance to create a confidence interval, often the interval is quite wide as is evident in this case. As Cormack points out, the right parameter should be regarded as a correct upper confidence level, while the left parameter should be regarded with caution because the capture – recapture prediction distribution is skewed to the right and therefore, we expect there to be a bias with the left parameter. Fienberg (1998) has recommended using profiling of intervals as a means for reducing the confidence interval and to eliminate the possibility of a left parameter that is less than the actual observed cases. For purposes of this research, this point estimate is a good indicator of the prevalence of victims of intimate partner violence and is within expected limits.

Table 4.7 Estimated Number of Women by Model

Number of Samples	Model	(a) Observed cases	(b) Prevalence MLE	Sum (a+b) Estimated Prevalence
3	2	520	734	1,254
3	3	520	545	1,065
3	4	520	1,796	2,316
3	5	520	388	908
3	6	520	3,139	3,659
3	7	520	1,817	2,337
3	8	520	5,853	6,373
2	1 vs. 2	320	2,275	2,595
2	1 vs. 3	464	2,061	2,525
2	2 vs. 3	416	747	1,163

X. Female-on-Male Violence

The prosecutor's database contained 45 reported women who assaulted men. The domestic violence shelter reported zero cases of men seeking shelter from women and the outreach had two males claiming to have been assaulted by females. Using the two source restricted model (see Table 4.4) there is an estimated prevalence of 137 male victims over the course of two years and seven months.

These estimates of female-on-male violence should be regarded with extreme caution for several reasons. First, the intersection between the prosecutor's database and the outreach database only contained one case. This is an extremely small sample and overlap with which to make reliable estimates.

Second, there are only two sources on which the estimations are based. Controlling for dependencies in this model is impossible and it is likely that the assumption of independence is violated.

Third, there is some question as to the validity of these being real cases of female perpetuated violence against males. The majority of these cases are from the prosecutor's database which come from police reports. Due to the new arrest laws, police officers have more authority to arrest perpetrators of Intimate Partner Violence (IPV).[17] In fact, police officers are encouraged to arrest perpetrators with fewer criteria.[18] This creates a bias in

[17] ARREST WITHOUT A WARRANT; ASSAULT AND BATTERY OR INFLICTION OF SERIOUS INJURY WITHIN HOUSEHOLD [MCLA 764.15a (1980)].
This law is commonly known as the domestic violence warrantless arrest statute. It allows the police officer to make an arrest if the officer has "reasonable cause" to believe that an assault has taken place, or is taking place, and that the person who committed the violation is a spouse, former spouse, or a person who resides or who has resided in the same household as the victim, or has a child in common with the victim. Under these circumstances, the officer may arrest the suspect without a warrant, whether the violation was committed in the presence of the officer or not.

[18] S. HB 4360 - P.A. 69 of 1994. Effective 7-1-94. Amends the Code of Criminal Procedure by requiring police agencies to establish written policies regarding their response to domestic violence by January 1, 1995. Policy requirements include an emphasis on arrest as the preferred response upon a finding of

the system as frequently women who have been victimized by intimate partner violence are arrested for physically defending themselves or reacting physically to a perceived threat of physical violence (Browne, 1987). Hamberger (1990) found that after the institution of domestic violence mandating arrest laws – women were found to be arrested at a twelve fold increase while men's rates of arrest only doubled.

Thirteen out of 45 (29%) of the female-on-male cases in this study were dismissed by the judge due to insufficient evidence or were not proven guilty beyond a reasonable doubt. In contrast only 20% of the male-on-female assaults were dismissed due to insufficient evidence or failure to prove guilt. Upon further analysis it was found that 33% women charged with domestic assault/assault and battery in court had histories of being battered by the same male. In one of the cases, the police arrested both the woman and the man for fighting. Twenty percent (9) of these women had been beaten on multiple occasions by this same male. The most extreme case is a woman who sought shelter or contacted the police ten times within the time period of this study. Eight of these women have been in the same court previously with the same partner, only the man was the suspect in the previous cases. None of these women in this study had received a jail sentence as a result of assaulting a male while 23% of the men received a jail sentence. Three percent of the male victims were treated at the hospital for injuries while twice as many women were treated.

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probable cause that a crime was committed in a domestic situation. Provisions for insuring victim safety and assistance are also required.

XI. Conclusions

In this chapter research questions three and four are addressed. *Does older couple violence compare to younger couple?* In this analysis we found that there are significantly fewer cases of abuse among older couples than among younger couples (1102 verses 404). However, there are significantly fewer older women at risk meaning there are fewer older women involved in an intimate relationship. The American trend of females marrying older males along with longer life expectancies of women, has left more older women single in their later years than younger women (State Demographer, 1997).

In these analyses, it is apparent that although fewer older women are being battered, they do not appear to be more elusive and invisible than younger women. The total population estimate of older women is explained by 37% of the observed population. For younger women, the percentage is only minimally higher (38%). The fourth research question, "*Are women as likely to perpetuate violence as men?*" is clearly answered. Based on these analyses it appears that men are more than 17 times as likely to physically assault their intimate partner. While there is evidence some females do perpetrate violence against males, it is not clear the contextual setting for that violence. In the qualitative analyses of these cases, there appears to be significant evidence that a large proportion of the female-on-male violence cases may be victims of domestic violence acting in self-defense. Furthermore, the changes in the criminal laws make it necessary for police to arrest all perpetrators of physical violence - - even if she is female and regardless of the context of the violence.

In sum, the statistical technique capture-recapture is able to estimate the prevalence of intimate partner violence for Marquette County. Based on the data from the prosecutor's office, the domestic violence shelter, and the outreach services, there were only 520 documented incidents of male perpetrated violence against a female intimate partner over the course of two years and seven months. Based on the capture recapture indirect estimates of domestic violence, it is more likely that the actual number of number of victims is closer to 2,337. This suggests that the official case records only account for approximately twenty-two percent of the total number of victims and 6.5% of the incidents.

CHAPTER 5 – COMPARATIVE STUDIES OF INTIMATE PARTNER VIOLENCE

I. Introduction

This dissertation has established that intimate partner violence has several methodological issues to overcome in estimating incidence and prevalence. In addition to measuring the frequency, there are other outstanding challenges to this field. Intimate partner violence estimation also involves defining what constitutes violence and who are its victims. These parameters are as varied as the researchers that approach the issue. This chapter will discuss differences between two national surveys and a recent statewide study in Michigan. This study will also demonstrate how the methodologies lead to varying results as well as limitations. Finally, the results of the surveys will be compared with estimates from the capture-recapture study described in the preceding chapter.

II. Survey Studies

A. Michigan Violence Against Women Study

In 1996, the Michigan Department of Community Health and Health Research Associates, in conjunction with the Centers for Disease Control and Prevention and the Gallup Organization, developed a survey to improve the knowledge of the prevalence and characteristics of violence. This study was modeled after the first national survey on violence against women in Canada (Statistics Canada, 1993). There were 1848 women interviewed for the Gallup study on violence. The overall response rate was 51.8% and the refusal rate was 17.2%. The sample was analyzed using SUDAAN statistics software to control for sampling effect.

1. Sample

The sample was obtained from random digit dialing and one woman was randomly selected once the household contact was initiated. Respondents were limited to women between the ages of 18 and 69. The data were weighted to represent the overall Michigan population.

2. Marital Status

This study includes all single, married, divorced, and never married women.

3. Definition

The respondents were asked regarding violent behaviors so that women would report "*violent acts*" that they may not normally have reported as violence. For example, instead of asking women if they were involved with a batterer, they would query whether certain acts occurred to them. Violence was defined as any threats, objects thrown at victim, pushed, grabbed, shoved, slapped, kicked, bit, hit, choked, beaten, used weapon, and forced sexual activity.

4. Gender

The focus of this study was violence against women, therefore, no males were interviewed.

5. Rates

There were 3.2% of the women in the Violence Against Women Study for Michigan who reported being physically assaulted by their intimate partner in the past year. That rate increases to 4.8% when we only consider the percentage of women involved in an intimate relationship or at risk as opposed to the general population of women. This rate of violence experienced by a current partner is less than half the proportion of the population that Straus and Gelles found in their survey, the National Family Violence Survey, but nearly three times as high as the rates found in the National Crime Victimization Survey.

B. The National Crime Victim's Survey

The Bureau of Justice Statistics commissioned the ongoing survey the National Crime Victimization Survey. This survey began in 1972 and has continued to the present.

1. Sample

This sample was designed using stratified, multistage cluster sampling. After a housing unit was selected, every resident from that unit was interviewed by the US Census. All persons age twelve and older were included in the survey. This survey generated a response rate of 96%. This study contained 101,000 persons from 50,000 housing units.

2. Marital Status

This study includes all persons for single, married, divorced, and never married persons.

3. Definition

Violence was defined as any attack or threat with a weapon such as a bat, pan, scissors, stick; thrown item such as rock or bottle; grabbing, punching, choking, rape, attempted rape or other sexual attack, and face to face threats.

4. Gender

Based on the revised National Victimization Survey, the rate for female victims was more than six times higher than the rate for male victims.

5. Rates

This survey created rates of intimate partner violence as 9.3 per 1000 for females and 1.4 for males. This rate is less than a tenth of the estimates found in the National Survey of Family Violence.

C. The National Family Violence Survey

The National Institute of Mental Health sponsored the National Family Violence Survey conducted in 1976 and again in 1985. The primary investigators of both of these studies were Murray Straus from the University of New Hampshire and Richard Gelles

from the University of Rhode Island. The response rate for this survey was 84% (Johnson, 1995).

1. Sample

The survey comes from a national random sample of 6,002 persons.

2. Marital Status

This survey was limited to persons who were married or cohabiting at the time of the study.

3. Definition

Violence was defined as, *"an act carried out with the intention or perceived intention of physically hurting another person"* (Gelles and Straus, 1990).

4. Gender

Based on both waves of the National Family Violence Survey, Straus and Gelles suggest that women perpetrate violence against men[19] more than men perpetrate violence against women. They found evidence of this in both mild and severe forms of violence.

5. Rates

This survey sets the proportion of couples experiencing violence at 11% and 12% perpetrated by males and females respectively for currently married or co-habitating.

[19] Although women reported slightly higher rates of perpetration than men, these differences were insignificant.

III. Comparative Estimates from Capture-Recapture

1. Sample

The capture-recapture analysis is based on three institutional data sources from Marquette County, Michigan for 1995-1997. Those data sources include authorized cases of violence perpetrated by an intimate partner of the Marquette County Prosecutor's office, records of women who stayed in the domestic violence shelter, and battered women who sought counseling services.

2. Marital Status

This analysis included all persons single, married, separated, and divorced.

3. Definition

Violence was defined as any physical assault.

4. Gender

Both males and females were considered for this study as long as they were victimized by a person of the opposite sex. Based on the capture-recapture analyses it appears that men are more than 17 times as likely to physically assault their intimate partner than females. This is the same sex disparity found in Kincaid's (1982) study of court files in Ontario, Canada.

5. Rates

The prevalence estimates generated from the capture-recapture analysis in the preceding chapter sets the annual intimate partner violence rate at 4.7% for female victims aged 18-69. This proportion is not directly comparable with those persons surveyed in the Michigan study, the National Crime Victim Survey or the National Family Violence Survey because those rates are only based on varying age groups and marital status. However, for comparison purposes Table 5.1 loosely demonstrates the varying rates. If we only look at women who are "at risk" for abuse, the number of women with an intimate partner is used as the denominator to calculate a "mate-rate". The Michigan Violence Against Women survey derived the rate for women with intimate partners at 68% for the state of Michigan. Using this proportion of the population of women aged 18-69, the number of women in relationships who were assaulted at least once within the year is 17%. This proportion is higher than Straus and Gelles found in their two national surveys by approximately 5-6%.

Table 5.1 Survey Estimates

Survey	Victim Annual Prevalence	Parameters
Michigan Violence Against Women	3.2%	All women
	4.8%	Women involved in relationship
National Crime Victim Survey	0.93%	All women
National Family Violence Survey	11.0%	All currently married or cohabiting women
Capture-Recapture	4.7%	All women
	17.0%	Women involved in relationship

IV. Methodological Limitations and Variances

The varying results of the intimate partner violence studies are a function of methodological differences as well as limitations. Methodological choices can serve to deflate and inflate estimates of intimate partner violence.

A. Intimate Partner Status

If only married and co-habitating women are studied as victims of intimate partner violence, a significant portion of the population is excluded. Rosenberg (1991) found "*Married women are the least likely, and single, separated, and divorced women the most likely, to experience assault by a male intimate*" (page 135). The National Crime Survey data show that separated women experience much higher rates of violence. In fact, the period when women are separating from their male partners is the most dangerous time of a relationship (Browne, 1987) . Jones (1994) found the time period when women separate from their male partner is when most homicides occur. Rosenberg (1991) reports that 16% of women presenting for medical assistance due to intimate partner violence are married, whereas 55 percent of assaults among separated women are perpetrated by a male intimate. Excluding respondents who are not currently involved in a domestic relationship or who have terminated an intimate relationship eliminates a large proportion of the violent population. Bachman and Saltzman (1995) found that rates of intimate partner violence for separated women are more than eight times as high as those for married women.

B. Survey research

Survey research precludes respondents who are severely victimized and isolated by their abuser from participating in the survey. Sample bias is a reality for all researchers; however, for intimate partner violence researchers the problem is confounded by the very nature of being a battered woman. First, if it were possible to interview battered women in representative surveys, there is substantial evidence that victims as well as perpetrators do not disclose violence (Johnson, 1995). Researchers have found that women report being abused more than their assailant reported abusing her (White and Koss, 1991; Stets and Henderson; 1991; DeKeseredy and Kelly (1993). Finally, the same characteristics of being a battered woman would also prevent her from being included in a random sample. Survey respondents and nonrespondents can differ significantly. The dynamics of battering include extreme isolation and fear of reporting (Pence, 1996) which has been systematically reported in multiple studies. "*Men who systematically terrorize their wives would hardly be likely to agree to participate in such a survey, and the women whom they beat would probably be terrified at the possibility that their husband might find out they had answered such questions*" (Johnson, 1995). Some of the tactics used by abusers (Pence, 1996) that would prevent victims from participating in a survey include:

- locking her in the home.
- calling her frequently during the day to make sure she is there and to make sure she is not on the phone.
- Threatening her with death if she leaves.
- Keeping her at home by not leaving her with a car or clocking the mileage on the car to prevent car usage.

Johnson (1995) found that in the National Family Violence Survey there were only a handful of women who reported abuse similar to the rate of women in shelters. After extrapolating this proportion of women to the population, he found the number of cases with severe levels of violence identical to shelter clients was far below the known number of women using shelters (Johnson, 1995). Battered women are not represented in national surveys. The very nature of the abuse prevents the victim from participating. Kirkwood (1993) reported victims having suffered so many blows, both physically and psychologically, they felt their assaults too trivial to report to an interviewer. Other victims reported not wanting to discuss such painful memories with a researcher (Smith, 1987).

C. Gender symmetry/asymmetry

Research conducted by Straus and Gelles (1990) indicates that women assault men slightly more than men assault women[20]. The Conflict Tactic Scales borne of the Family Violence Survey do NOT take into consideration the acts of violence it purports to measure. As multiple researchers point out, these results do not reflect the social reality because the survey instrument was designed in a manner that did not discern who initiated the violence, the size and strength of the persons involved, and the nature of the relationship[21] (Dobash, Dobash, Wilson, and Daly, 1992; Saunders, 1986; Adams Jackson, and Lauby, 1988; Berk, Loseke, Berk, and Rauma, 1983; Fields and Kirchner, 1978; Pleck, Pleck, Grossman, and Bart, 1978; Wardell, Gillespie and Leffler, 1983).

[20] These differences were found to be insignificant, Straus concluded that men and women batter each other equally as much.

The Conflict Tactic Scales have been utilized in other studies that qualified the violence perpetrated by women. When women were asked to estimate the frequency of their violence to prevent themselves from immediate harm, there was indication a significant portion of these women were indeed acting in self-defense (DeKeseredy et al, 1997; Saunders, 1986).

In the National Crime Victimization Surveys 1992-1996 and the 1994 Study of Injured Victims of Violence, three out of four female victims of domestic violence reported defending themselves during an assault (US Department of Justice, 1998). The implications of the Family Violence Survey of female initiated violence contrast dramatically with clinical studies of shelters and police departments, as well as those from another national survey (Dobash and Dobash, 1992; Martin, 1981; Kincaid, 1982). Gauquin (1978) found that 97% of the assaults were by males in the first National Crime Survey. Bachman and Saltzman (1995) found that women are more likely to be killed from husbands, boyfriends, and ex-partners than men.

For the Marquette study described in Chapter 4, further analysis reveals many of those women who were reportedly perpetrators of intimate partner violence have been victims of battering and further, those men who were recorded as victims have also been perpetrators of violence in previous occasions. This additional information gives doubt as to the legitimacy of many of those cases by providing a contextual background. Furthermore, in only one of those cases was it clear that the female had superior strength and a physical advantage over the male within the two years and seven months of this study.

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[21] There are other significant methodological problems outside the realm of this study with the Conflict Tactic's Scale as it attempts to provide some hierarchical model for various forms of violence based on a

D. Agency Studies

Studies conducted in hospitals, shelters and police departments are subject to serious clinical fallacy. Some of the reasons victims of intimate partner violence do not report to the police is they consider the incident a private or personal matter, they are afraid their perpetrator will retaliate, or they feel the police will not do anything (Bureau of Justice Statistics, 1998). Using clinical data as estimators for incidence excludes a large proportion of the cases.

Furthermore, studying characteristics of domestic violence on only those persons found in clinical samples cannot be generalized to the whole population. There may be significant differences from women in domestic violence shelters from women who were unsuccessful at leaving their abuser from women who were successful at leaving their abuser without the help of social service agencies. However, as long as some of those women are captured in those clinical data, then the technique of capture-recapture can estimate those women missing.

E. Pretense of Study

The Family Violence Survey was posed to respondents as a study regarding family violence and tactics couples employ to resolve conflict. The Michigan Study was posed as a study of several categories of violence perpetrated against women. In contrast, the National Crime Victimization Survey approaches potential respondents as a general study of crime. Many victims of domestic violence still do not see this brand of violence as a crime (VAWNET, 1998). This may explain part of the varying rates.

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preconceived danger potential.

F. Respondents

The National Crime Victimization Survey interviews all members of the selected household. Victims may be reluctant to disclose assaults they experienced by members of the same household. The victims may also be uncomfortable reporting events that are in conflict with the reports of their assailant. Both the Michigan study and the Family Violence Survey only interviewed one person from the household which may have left the victims more open to disclosure and may also explain part of the discrepancy in the estimates.

G. Age Parameters

The Michigan Study did not include women younger than 18 or older than 65. This would act as an inflating factor because persons in the highest risk age groups are those persons 19-29 (Bachman and Salzman, 1995). The Michigan study includes that age group but excludes those women who are in known lower risk groups. The National Crime Victimization Survey includes persons in the 12-18 group and 65 + group which will deflate the rates of violence. Women are more likely to be widowed and single and the least likely to experience domestic violence and they are included in this survey (VAWNET, 1998).

H. Bounding

The Michigan Study and the National Family Violence Survey are not longitudinal studies such as the National Crime Victimization Study. Respondents are

asked in all three studies to recollect over the past year incidents of violence. In the first two studies, the victim may very well misremember events that happened within the specified time frame. Respondents may report an event that occurred before the time period of interest. In contrast, the National Crime Victimization Survey is given on a six month basis and when victims report an incident, it is check against their previous record and respondents are queried whether the stated incident is indeed a new event or one that was mentioned in the previous wave. Bounding prevents respondents from including incidents from outside the time period of interest. Studies have shown unbounded interviews tend to overproduce estimates of incidents (Bachman and Taylor, 1994).

V. Conclusions

In sum, measuring violence perpetrated by an intimate partner or ex-partner will always be a methodological challenge. DeKeseredy and Schwartz (1996) reported it was impossible to obtain totally accurate data and that some methods were more reliable than others. Given their conceptual framework, they were correct to think that the *"best procedures are representative sample self-report and victimization surveys specifically designed to collect data on male-to-female violence"* (page 330). DeKeseredy and Schwartz made recommendations to increase the validity and reliability of survey research as they knew institutional records were gross undercounts. Nonetheless, capture-recapture remains a viable option to overcome many of these sampling issues in estimating woman battering frequency.

In response to the second research question, '*are there significantly more cases of domestic violence than are reported or estimated from surveys?*' The estimates from

capture-recapture are higher than the Michigan Violence Against Women Study, the National Crime Victim's Survey, and the National Family Violence Survey. Survey research is known to exclude victims of intimate partner violence as well as police or shelter registries. Capture-recapture can estimate the proportion of persons missing from both research strategies and empirically demonstrated, there is a large number of victims missing from traditional estimation procedures.

CHAPTER 6 – CONCLUSION

I. Summary of Dissertation

A. Theoretical Lull

This dissertation employs new research methods to study violence and to open up the theoretical development in a fledgling field with stagnate theoretical progress. Sociologists, along with psychologists and criminologist largely ignored woman battering until the seventies. The *Journal of Marriage and the Family*, one of the most prestigious and highly read journals for sociologists, has been in existence for 60 years. Not a single article discussed intimate partner violence for the first 30 years (O'Brien, 1971). Sociologists only broached the topic of wife abuse as recently as the 70's. Primarily those researchers were "*family sociologists*" who were in the process of exchanging the traditional *functionalism* as a research framework for *conflict theory*. *Family violence* sociologists are a product of the early 1970's Civil Rights and Vietnam War era and have not developed their theoretical frameworks much beyond those of the early days.

Although Straus (1973) has subscribed to *General Systems Theory* and Gelles (1983) supports *Exchange and Social Control Theory*, these two theories are based on the same *family violence* framework. Both place violence in the family system and conflict. The former theoretical framework implies that violence is a universal part of a family system and that the system itself regulates the levels of violence. The latter framework suggests violence is used as a means to gain something unless there are significant costs. While both these theories supply separate etiologies for the use of violence, both these theories normalize violence by assuming violence is a normative reaction - - either as a

response to conflict or as a means to gaining something from the partner. When Straus (1973) proclaimed the "*marriage license is a hitting license*" he was merely trying to emphasize the pervasiveness of spouse abuse. However, implicit in this statement is the belief violence is a normal tactic with full family participation.

The family violence theorists have failed for the past three decades to explain the disparity between social reality and their research findings. Furthermore, violence is a complex issue where all forms cannot be understood within a single framework, regardless if that framework has developed into a meta-theoretical level as Gelles has suggested (1995). The etiology of fathers raping their daughters differs significantly from men battering women or adult children abusing elder parents. These various forms of family violence must be desegregated to be understood. It is even probable that there is more than one distinct form of women battering (Johnson, 1995). Theoretical development for family violence must occur independently.

Family violence theorists acknowledge sexism and patriarchy as a significant factor in partner abuse, but still violence is conceptualized from the family structure where it is plausible either partner initiates the violence as a normal response to everyday conflicts or as a means to gain power over a partner. Feminist researchers are better able to explain intimate partner violence as rooted in the patriarchal structure but have only recently begun to consider various motivations and types of woman battering. A univariate explanation of woman battering does not explain some of the significant findings of other researchers. The feminist perspective provides the best explanation for battered women even though it requires further development.

B. Theoretical Impasse

This dissertation takes a novel methodological approach to intimate partner violence to test existing theoretical frameworks and resolve the feminist/family impasse. The results of this dissertation find supporting evidence for the *feminist framework*. Since the inception of violence research, advocates for battered women and their research counterparts, *feminist theorists*, have been at odds with the family sociologists. The irreconcilable difference is rooted in the tenet of *family violence theorists* that women assault men equally as much as men batter women and that violence is a normal, albeit unacceptable, part of married life. Ultimately, family theorists find support for these allegations in their research while feminist theorists find contradictory evidence. In fact, feminist researchers find very little if any evidence that women assault men, except under the auspices of self-defense. This dissertation could resolve some of the polarization of subscribers of the *family violence theory* and the *feminist theory*.

C. Methods Suspend Theoretical Development and Testing

The methodology used in this dissertation is a new medium to study woman battering to lead to theoretical development. *Family violence* sociologists have theorized based on two national surveys (Straus and Gelles, 1973; 1985) while feminist researchers primarily have collected their data from clinical trials. There are exceptions where feminist researchers use surveys and family violence researchers rely on clinical trials (Johnson, 1995), but still these two divergent theorists stand by earlier holdings. The national surveys do not yield findings consistent with the clinical trials conducted in hospitals, police departments, courtrooms, and domestic violence shelters.

Inherent in studies of woman battering are serious methodological barriers. Survey researchers are not able to get an accurate depiction of woman battering because their studies could not possibly be a representative portion of the population since victims must be missing (Johnson, 1995). The very nature of intimate partner violence precludes the victims from such activities as leaving their home, using a car, using the telephone, and spending time with other people (Pence, 1996). These activities are essential for participants of survey research.

Similarly, clinical trials cannot describe victims who never seek help or report their assailant. As feminist researchers acknowledge, the victimized population is mostly undercounted (Yllo and Bograd, 1988). The sampling bias of non-representation and clinical fallacy have left feminist researchers and family sociologists stunted in their theoretical development. This dissertation has demonstrated a means to describe those victims that never report battering as well as enumerating those women who are missing from survey research. This dissertation has overcome these monumental research barriers in woman battering research.

For Sociologists, social reality, methodology, and theory are closely tied to each other. Methodology allows us to test our hypotheses to establish our theory creating an intrinsic dependence. Theory establishes the demand put on the methods which "open up" the theory. Sociologists theorize but are unable to critically examine theory with limited methods. If there is theoretical development, the theories cannot be critically examined with limited methodologies. This has been the case of the two major theoretical frameworks used in domestic violence. This dissertation has methodologically pushed the

general body of knowledge in the field of violence research forward by overcoming the methodological limitations of violence researchers.

D. Capture-Recapture

This dissertation has allowed for the victim population to be counted even when victims did not report the assault to the police or a social service agency and when victims were not represented in surveys regarding violence. The hidden population of victims is counted using capture-recapture as well as those persons known to be battered. These findings do not support the status quo, the *family violence* framework, even though mainstream sociologists are the dominant, most accepted, and quoted ideology in the field of domestic violence research (Yllo, 1995). Their contentions of gender symmetry in intimate partner violence is not supported. In contrast, the capture-recapture estimates found it extremely rare for men to be assaulted by women. Further qualitative investigation revealed that a significant portion of the men who were assaulted by women had frequently battered that same woman on previous occasions. Furthermore, some of those "*male victims*" had severely and frequently battered their female partners which suggests those women may have been acting in self-defense or assaulted their male partners unprovoked because of a perception of vulnerability (Browne, 1987).

Another finding from the capture-recapture estimates is the significant number of older battered women. This dissertation provides challenging results as to the age structure of the victimized population. Generally, women victims are thought to be quite young (Stark and Flitcraft, 1991) when in fact, the average ages of victims from this analysis and from case records suggest a much older population in the case of Marquette

County. Stark and Flitcraft (1991) suggest violence is more common among women under the age of 30 while they did acknowledge older women were victimized as well. Results from the data placed the average women who frequented shelters in her mid 30's. In addition, there were several cases of woman battering by an intimate partner for women who were at the end of their lifespan. A significant portion of the battered women's population is invisible increasing the difficulty to characterize that population. While these results are not in contradiction to any theoretical speculations about age and violence, it does give us a better profile of the population.

This study has provided better point estimate of frequency of intimate partner violence in terms of both prevalence and incidence. Although the capture-recapture rates are not directly comparable to other state and national surveys as well as institutional studies, it appears a much larger proportion of the population is being battered in a given year than indicated in the Michigan Violence Against Women Survey, National Crime Victim's Survey, and the National Family Violence Survey.

Capture-recapture is a compelling estimation technique first used by wildlife researchers (Peterson, 1896; Lincoln, 1930), briefly used and forgotten by demographers (Sekar and Deming, 1949), borrowed by epidemiologists (Wittes and Sidel, 1968), improved by statisticians (Fienberg, 1972: Bishop et al., 1975) and fortunately, employed once again by demographers (Nanan and White, 1997). The application of capture-recapture is becoming a more common and acceptable means of indirect estimation. Recently, there have been innovative applications of this technique. The US government is using capture-recapture to control for undercounting in the US Census (Nanan and White, 1997). Epidemiologists are using capture-recapture to estimate the size of illegal

and covert populations such as prostitutes (McKeganey et al., 1992), homeless persons (Fisher et al., 1994), and heroin users (Squires et al., 1995; Barnes, 1995). NASA has employed this technique to count the number of stars in the universe (Fienberg, 1998). Currently, the British Society for Statistics has research underway to estimate the size of the World Wide Web (Fienberg, 1998). Capture-recapture is being used in a creative fashion to estimate some difficult research areas.

This dissertation has employed simulations to test the capture-recapture technique to determine the sensitivity, the precision and the distribution of the model. Controlled experimental simulations were able to demonstrate how sensitive the model is to the probability of being captured and the importance of matching the data. The sensitivity decreases as the sample size and overlap increases. If there are errors in the intersections of data identification, the effects are doubled in the skewing of the results. These simulations also show the effect of being captured in one or more samples while using the capture-recapture technique.

Further simulations demonstrate capture-recapture the precision of the technique in forming point estimates substantially increases when the observed cases represent more than 15% of the estimated cases. When the ratio of observed to estimated cases drops below the 15% mark, the confidence interval grows substantially. Still, even with the larger standard errors, profiling the intervals using a variety of techniques can give the researcher a better notion of the true population size than by not using the capture-recapture technique.

Some researchers have been reluctant to accept this indirect estimation procedure as a valid and reliable technique (Hay, 1997). However, statistical controls and

innovations of capture-recapture have assured this is a valid and reliable technique. There have been several refinements and varied means to control the violations of necessary assumptions[22] by some outstanding statisticians (Fienberg, 1972; Bishop et al., 1975; Fienberg, 1998; Cormick, 1981; Ding, 1990; Ding and Fienberg, 1994; Sekar and Deming, 1949; Alho, 1990; Alho et al., 1993; Erickson and Kadane, 1985; Darroch et al., 1993; Agresti, 1994; Kelderman, 1984; Agresti and Lang, 1993; Biggieri et. al., 1997). This technique has been victim of excessive criticism probably based in its unusual origins and characteristics. That coupled with its deviation from traditional research strategies has cast further doubt. The basic structure of the technique and the statistical controls require a sophisticated and high level of statistical knowledge. These simulations demonstrate the ability of capture-recapture to estimate the size of a known population with exceptional precision.

The simulations demonstrate this technique is a valid and reliable methodology and also illustrate the need to meet the necessary assumptions. If those assumptions are violated[23], it is necessary to employ statistical controls and techniques. As long as a researcher can successfully employ those techniques while using capture-recapture, the method will be valid and reliable.

In sum, capture-recapture has successfully been used to estimate the prevalence of intimate partner violence. This novel approach to intimate partner violence should shed light on this complicated social problem and push the body of generalizable knowledge ahead on who are the victims and the pervasiveness of the problem.

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[22] The majority of these techniques were either unnecessary or not applicable to the research at hand and therefore, there is little discussion of these other controls. Several researchers are currently in the process of refining these statistical controls even further.

[23] Researchers should assume this to always be the case.

II. Significance of Study

A. Paradigm Shift

Capture-recapture has held up as a feasible and viable option for estimating the population of victims of intimate partner violence in this dissertation. It proved to be an excellent means of estimating the size of the population when the registries of the shelter, the outreach program, and the prosecutor's office were known to contain accurate but not exhaustive cases. This study has provided violence researchers with a new paradigm for estimating the size of the victimized populations previously thought impossible to count (DeKeseredy and Schwartz, 1996).

B. Tests Existing Theories of Intimate Partner Violence

Until now, there has not been an alternative methodology to test the two major theories of intimate partner violence and to a 25 year old theoretical impasse. This dissertation lends support to the feminist framework for conceptualizing violence between intimates with gender asymmetry and women being the major victims of intimate partner violence. This dissertation also challenges the dominant theories of intimate partner violence known as the family violence perspective. This study has provided an additional approach to testing the theories of intimate partner violence while rising above the barriers of clinical fallacy and non-representation. This study has generated multiple estimates of intimate partner violence based on multiple samples which lend support to the feminist perspective.

C. Methods Have Provided Room for Theoretical Development

While this research has supported the feminist perspective, it has also enumerated women who went undetected in previous clinical trials and surveys. While the feminist perspective explains the scenario of women in shelters, police departments, court, and emergency rooms, it does not necessarily explain the etiology of the violence of those women who went undetected in previous studies. There is room for development within the feminist perspective to explain other forms of violence against women.

Family violence sociologists need to re-examine their holdings that women are battering men equally or even more than men batter women. Multiple studies, including nationally representative surveys, clinical studies, as well as this capture-recapture study find no support for this tenet of the family violence theories. Given there are trace examples of women assaulting men, the context of those injuries, the size disparity and the intent of the assailant need to be considered.

Ultimately, even if there is a small minority of women assailing their male partners, the proportion is not comparable and does not have the structural implications as female battering. Intimate partner violence is analogous to racism. Behind an act of discrimination by a white person comes with it the racial structural inequality of our society because whites are politically in control and hold the reigns to the economy, the workplace, the resources, and privilege. Even though it is possible to have reverse discrimination based on prejudice against a white person by a minority, it is NOT possible to have a person of color acting as a racist because that person is not in a societal position of authority. Violence against women is similar. Even though women may act in

violence against their male partners, it is still the men who hold the political and economic control and dominate women in a patriarchal structure where male privilege prevails. "Woman battering" should be considered a patriarchal structural issue. Although Steinmetz (1980) coined the term "husband-battering" and announced there was a hidden social problem of violence against males, there is no evidence this occurs except in isolated and rare events. To indicate otherwise, is a disservice to battered women and the credibility of sociology. Many battered women's advocates have gone so far as to accuse the family violence sociologists of damaging the necessary support for battered women by confounding these issues and digressing from the true social inequalities (Jones, 1994).

Reports of "husband battering" reach policy makers and are not always discerned from substantiated research. Support for battered women is controlled by the legislature who provide necessary funding to domestic violence shelters. In one example, a Michigan senator in 1998 placed the funding of the Pontiac shelter in jeopardy. While shelters do provide safe housing and counseling for male victims in locations outside the premises, this program was seen as discriminating. One man wanted to stay inside the shelter with the other battered women and children (one of them being his wife) but was referred to stay in another location. The funding that provided safety to hundreds of women and children in one of the largest and busiest shelters in the state of Michigan was at risk because of a perceived "battered husband". Shelters were alerted their funding would be jeopardized if battered men were refused entrance. The funding was not revoked, however, false alarms take valuable time and resources best left devoted to battered women. Researchers have a strong impact on policy makers who have the power

to help battered women and children. Researchers should focus their efforts on violence against women instead of creating distracting "false alarms". While it is appropriate to consider all scenarios, substantiation requires replication.

The discipline of family sociology and their research methodologies should be scrutinized carefully. Just as in the case of the family violence perspective, it is not plausible to study complex family issues and to develop one theoretical framework with which to explain all forms of violence. Family violence researchers are misguided in their theoretical development and it is not clear if part of this problem is rooted in the overall discipline as well.

D. Tests Precision and Sensitivity of Capture-Recapture

This dissertation has demonstrated that capture-recapture can be used with confidence to indirectly estimate the size of the population of battered women. However, in addition, the simulations used in this dissertation also develop the understanding about the technique itself by demonstrating how the technique holds up under various conditions. The simulations also generate a distribution to provide researchers with an understanding of the possible distribution of positively skewed estimates. Furthermore, the simulations develop a pattern of standard deviations of population estimates based on varying probabilities of being captured.

E. Future Applications

Capture-recapture can be used by sociologists for multiple purposes. First, the technique is an excellent means to estimate the size of the population when clearly there

are incomplete data available from two or more sources. Second, capture-recapture can be used to refine estimations from survey research. Third, this technique could be used in the evaluation of incomplete case ascertainment of registries and surveillance systems. Capture-recapture would be an excellent technique to measure other invisible populations that challenge social researchers such as sexual assault. The possibilities of this technique to open up the theoretical development and to test existing theories are compelling. For example, there is a twenty year debate between criminal justice theorists and feminist psychological theorists regarding the prevalence of rape. The sexual assault prevalence debate is even more heated than the family violence/ feminist gender symmetry/asymmetry argument. Criminal Justice researcher's response to the high levels of sexual violence reported in national sexual violence surveys have been received poorly. Feminist researchers have been accused of research strategies that invent victims of sexual assault (Gilbert, 1998). This technique could establish the pervasiveness of sexual violence and provide an objective perspective.

F. Limitations

1. Cannot Positively Differentiate Violence Types

This methodology cannot distinguish different types of violence without incorporating qualitative research methods. For example, Pillemer and Finkelhor describe violence among the elderly as stemming from caretaker stress as well as intimate partner violence that is comparable to younger couple violence. McLeer and Anwar (1989) conducted a study on intentional injuries in the emergency room in Philadelphia. These researchers noted there were several cases of teens who were mis-identified as cases of

child abuse and elders who were mis-identified as cases of elder abuse when in fact, they received injuries from their intimate partners. This technique can only tell the frequency of that violence and not the origins.

Johnson, (1995) suggests that instead of one form of intimate partner violence, there are in fact two forms - - Common Couple Violence and Patriarchal Terrorism. Common couple violence he believes is what is being measured by the Conflict Tactics Scale in Straus and Gelles Family Violence Survey (1995). Johnson states that, "*some families suffer from occasional outbursts of violence from either husbands or wives (common couple violence) while other families are terrorized by systematic male violence (patriarchal terrorism)* (page 282). The types of violence need to be desegregated before indirect estimation can occur.

2. Measures more severe forms of Violence and Only Physical Violence

The capture-recapture methodology can only measure those cases it captures in one or more institutional database. Even if there is only a small trace of less severe and non-physical types of violence, it will capture the rest of those cases in the missing cell. However, in the case of this study, those institutional databases include authorized cases from the prosecutor's office, shelter, and counseling. Those cases in the prosecutor's database only are included if there is ample evidence of physical abuse for the prosecutor to take the case assailant to trial. Generally, those cases required hospitalization or other emergency medical care. Ultimately, it is only those cases with the most evidence, meaning the most physical damage to the victim, that make it to trial or in the very least result in the arrest of the perpetrator. Similarly, the shelters only can house those women

with the most life threatening situations because of lack of space. Those cases are deemed more serious when there has been evidence of more extreme injuries. The files of the shelter residents contained photos of women with serious injuries such as bruises, swelling, cuts, and broken bones. Furthermore, the very nature of a "shelter" is an indicator of the severity of the violence because the residents are there because of their fear of harm from an intimate assailant.

Studies have revealed that on average the clients of shelters experience 65-68 beatings per year (Johnson, 1995). A necessary assumption of capture-recapture is that at least some of the cases be captured in the multiple case registries or the technique cannot estimate the missing cases. Since none of the women in all three of the databases appeared more than twenty times, we can assume the incidence estimations are undercounts. Less credence should be placed on the incidence for this reason, however, the measures of prevalence are adequately represented in a three data systems. Once capture-recapture establishes a better prevalence rate, a combination of capture-recapture with survey research could better determine the incidence and resolve this methodological barrier.

3. Does not provide individual level data

The capture-recapture techniques provides estimates of the population while it does not provide individual level data. While it is possible to produce estimates for total counts within categories such as age or racial groups, it is not possible to use the capture-recapture estimates for analysis of desegregated cases.

G. Conclusion

This study was able to provide better estimates and characteristics of victims of intimate partner violence by using the technique capture-recapture. This dissertation establishes capture-recapture as a powerful research technique to estimate the size of populations for empirically testing existing theories and for further theoretical development.

REFERENCES

Abeni, D.D., G. Brancato, and C. A. Perucci (1994). Capture-recapture to estimate the size of the population with human immune-deficiency virus type 1 infection. *Epidemiology*, 5: 410-14.

Alho, J. M. (1990). Logistic regression in capture-recapture models. *Biometrics*, 46: 623-35.

Anderson, Margo J. (1988). *The American Census: A Social History.* New Haven, CT: Yale University.

Babbie, Earl, (1994) *The Practice of Social Research* (7th Ed.) Wadsworth, Inc. Belmont, CA.

Baca-Zinn, Maxine, and D. Stanley Eitzen (1993). *Diversity in Families.* (3rd ed.) Harper Collins College Publishers.

Bachman, R. & Saltzman, L.E. (1995). Violence against Women: Estimates from the Redesigned National Crime Victimization Survey, (NCJ-154348). Bureau of Justice Statistics, U.S. Department of Justice.

Bachman, R. & Taylor, B. (1994). The measurement of family violence and rape by the redesigned National Crime Victimization Survey, Justice Quarterly, 11(3), 499-512.

Barg, M. S., and C. A. Huether (1983). A study of underreporting of Down's syndrome on birth certificates in an Ohio County, 1970-78. *Public Health Rep*, 98: 78-84.

Barnes, Suzie et. al. (1995) Michigan Heroin Prevalence Study 1994. College of Urban, Labor and Metropolitan Affairs. Wayne State University.

Bengtson, V. L., and Allen, K. R. (1993). The life course perspective applied to families over time. In P. G. Boss, W.J. Doherty, R. LaRossa, W.R. Schumm, and S. K. Steinmetz (Eds.), *Sourcebook of Family Theories and Methods, A Contextual Approach.* New York: Plenum.

Benn R. T., I. Leck, and U. P. Nwene (1982). Estimation of completeness of cancer registration. *Int. J. Epidemiology*, 11: 362-7.

Bersani, Carl A. and Huey-Tsyh Chen (1988) Sociological Perspectives in Family Violence. Handbook of Family Violence, edited by Vincent B. Van Hasselt, Morrison, Bellack, and Hersen. Plenum Press, New York.

Bishop, Y. M. M., S. E. Fienberg, and P. W. Holland (1975) *Discrete multivariate analysis: Theory and practice.* Cambridge. Cambridge, MA: MIT Press, 229-256.

Blau, P. M. (1964) *Exchange and power in social life*. New York: Wiley Press.

Bloor, M., A. Leyland, and M. Barnard, et al. (1991). Estimating hidden populations: a new method of calculating the prevalence of drug-injecting and non-injecting female street prostitution. *Br J Addict*, 86: 1477-83.

Browne, Angela (1987) *When Battered Women Kill.* New York : Free Press ; London : Collier Macmillan

Brecht, M. L., and T. D. Wickens (1991). A comparison of multiple-recapture models for drug prevalence estimation. *American Statistical Association 1991 Proceedings of the Social Statistics Section,* 556-61.

Brecht, M. L., and T. D. Wickens (1993). Application of multiple-capture methods for estimating drug use prevalence. *J Drug Issues*, 23: 229-50.

Bruno, G., G. Bargero, and A. Vuolo, et al. (1992). A population-based prevalence survey of known diabetes mellitus in northern Italy based upon multiple independent sources of ascertainment. *Diabetologia*, 35: 851-6.

Campbell, J., P. Miller, M. Cardwell, and R. Belknap (1994) Relationship Status of Battered Women Over Time. *Journal of Family Violence*, 9 (2) 99-111.

Chapman, C. J. (1983). Ethnic differences in the incidence of cleft lip and/or cleft palate in Auckland, 1960-1976. *N Z Med J*, 96: 327-9.

Chiu, W. T., S. R. Dearwater, D. J. McCarty, et al. (1993). Establishment of accurate incidence rates for head and spinal cord injuries in developing countries: a capture-recapture approach. *J Trauma*, 35: 206-11.

Clausen, J. (1986). *The Life Course: A Sociological Perspective.* Englewood Cliffs, NJ: Prentice Hall.

Cochi, S. L., L. E. Edmonds, K. Dyer, et al. (1989). Congenital rubella syndrome in the United States, 1970-1985: on the verge of elimination. *American Journal of Epidemiology*, 129: 349-61.

Davis, S. F., P. M. Strebel, and W. L. Atkinson, et al. (1993). Reporting efficiency during a measles outbreak in New York City. *Am J Public Health*, 83: 1011-15.

Decalmer, P. and Glendenning, F. (1993) *The Mistreatment of Elderly People.* Newbury Park, CA: Sage.

DeKeseredy, W., and M. Schwartz (1993) "Male Peer Support and Woman Abuse: An Expansion of DeKeseredy's Model." *Sociological Spectrum* 13:393-413.

Demaris, Alfred, (1992). *LOGIT Modeling: Practical Applications.* Series: Quantitative Applications in the Social Sciences. A Sage University Paper.

Dobash, R. E., and Dobash R. P. (1979). *Violence against wives.* New York: Free Press.

Doscher, M. L., J. A. Woodward. (1983). Estimating the size of subpopulations of heroin users: applications of log-linear methods to capture/recapture sampling. *Int. J Addict*, 18: 167-82.

Drucker, E., and S. H. Vermund (1989). Estimating population prevalence of human immunodeficiency virus infection in urban areas with high rates of intravenous drug use: a model of the Bronx in 1988. *American Journal of Epidemiology*, 130: 133-42.

Edleson, Jeffrey L. and Richard M. Tolman (1992). Intervention for Men Who Batter: An Ecological Approach. *Intimate partner Violence: The Practice Series.* Sage Publications.

Espeland, M. A., W. C. Murphy, and D. H. Leverett (1988). Assessing diagnostic reliability and estimating incidence rates associated with a strictly progressive disease: dental caries. *Stat Med* 1988;7:403-16.

Fagan, J. A. (1989) "Cessation of Family Violence: Deterrence and Dissuasion." In Ohlin, L. and Tonry, M. (eds.) Family Violence. Vol. II: Crime and Justice An Annual Review of Research. Chicago, IL: University of Chicago Press.

Faulkner, Lawrence R., (1982) "Mandating the Reporting of Suspected Cases of Elder Abuse: An Inappropriate Ineffective and Ageist Response to the Abuse of Older Adults." Family Law Quarterly, Volume XVI, Number 1, Spring.

Featherman, D. L. and Lerner, R. M. (1985). Ontogenesis and sociogenesis: Problematic for theory and research about development and socialization across the lifespan. *American Sociological Review,* 50, 659-676.

Fienberg, Stephen E. (1972) The multiple recapture census for closed populations and incomplete 2^k contingency tables. *Biometrika,* 59, 3, 591-601.

Fienberg, Stephen E. (1998) *Innovative Methodology for Capture Recapture Studies.* Workshop Notebook from the North Eastern Biometrics Conference, Pittsburgh, PA. March 31, 1998.

Fisher, N., S. W. Turner, and R. Pugh, et al (1994). Estimating numbers of homeless and homeless mentally ill people in north east Westminster by using capture-recapture analysis. *BMJ*, 308: 27-30.

Frischer, M. (1992). Estimated prevalence of injecting drug use in Glasgow. *Br J Addict*, 87:235-43.

Frischer, M. and A. Leyland (1992) Reliability of population and prevalence estimates. *Lancet,* 339: 995.

Frischer, M., A. Leyland, and R. Cormack, et al (1993). Estimating the population prevalence of injection drug use and infection with human immunodeficiency virus among injection drug users in Glasgow, Scotland. *American Journal of Epidemiology*, 138: 170-81.

Frischer, M., M. Bloor, and A. Finlay, et al (1991). A new method of estimating prevalence of injecting drug use in an urban population: results from a Scottish city. *Int. J Epidemiology*, 20:997-1000.

Frischer, M, S. T. Green, and D. J. Goldberg DJ, et al (1992). Estimates of HIV infection among injecting drug users in Glasgow, 1985-1990. *AIDS*, 6:1371-5.

Gelles, R. J. (1997). *Intimate Violence in Families.* 3rd. Ed. Sage Publications.

Gelles, R. J. (1974). *The violent home: A study of physical aggression between husbands and wives.* Newbury Park, CA: Sage.

Giordano, N. and Giordano, J. (1984) Individual and Family Correlates of Elder Abuse. Bradenton, Fla.: Unpublished Manuscript.

Glick, P. C. (1992) American Families: As they are and were. In A. S. Skolnick and J.H. Skolnick (Eds.), *Family in Transition* (7th ed.) New York: HarperCollins.

Goldberg, I. D., and I. F. Wittes (1978). The estimation of false negatives in medical screening. Biometrics, 34:77-86.

Gondolf, Edward W., Yue-Fang Chang, and Ronald Laporte (1997) Capture-Recapture Analysis of Batterer Reassaults: An Epidemiological Innovation for Batterer Program Evaluation. Submitted to *Violence and Victims.*

Goode, W. J. (1971) Force and violence in the family. *Journal of Marriage and Family,* 33, 624-636.

Gutteridge, W, and C. Collin (1994). Capture-recapture techniques: quick and cheap. (Letter). *BMJ*, 308: 531.

Hageboeck, H. and Brandt, K. (1981) Characteristics of Elder Abuse. Iowa City: University of Iowa Gerontology Center, unpublished manuscript.

Hall, S.S. (1992) How technique is changing science. *Science* 257: 244-9.

Hartnoll, R, R. Lewis, and M. Mitcheson, et al (1985). Estimating the prevalence of opium dependence. *Lancet*, 1: 203-5.

Hay, Gordon (1997) The selection from multiple data sources in epidemiological capture-recapture studies. *The Statistician*, 46, No. 4, pp. 515-520.

Hayse, Ellen, and Thomas Kuecker, Chun-Hao Li, Lori A. Post-Wibert, Nathaniel Read Silver. (1998) *Community Response to Domestic Violence: A Guide for Developing Agency Collaboration.* The Violence and Intentional Injury Prevention Program. Institute for Children, Youth, and Families. Michigan State University.

Hewitt, D, and J. Milner (1970). Prevalence of hemophilia in Ontario, 1966. *Can Med Assoc. J*, 102: 174-7.

Hershel and Hutchinson (1993). Police preferred arrest policies, 1991. In *Woman battering policy responses* by Steinman, Michael; Anderson Publishing Co Cincinnati.

Hilsenbeck, S. G., C. Kurucz, and R. C. Duncan. Estimation of completeness and adjustment of age-specific and age-standardized incidence rates. *Biometrics*, 48: 1249-62.

Homans, G. C. (1961) *Social behavior: Its elementary forms.* New York: Harcourt, Brace, Javanovich.

Hook, E. B. (1993). Re: "Use of Bernoulli census and log-linear methods for estimating the prevalence of spina bifida in live births and the completeness of vital record reports in New York State." (Letter). *American Journal of Epidemiology.* 137: 1285

Hook, Ernest B., Ronald R. Regal (1993) Effect of Variation in Probability of Ascertainment by Sources (Variable Catchability) upon "Capture-Recapture" Estimates of Prevalence. *American Journal of Epidemiology.* Vol. 137, No. 10.

Hook, Ernest B., Ronald R. Regal (1995) Capture-Recapture Methods in Epidemiology: Methods and Limitations". *Epidemiologic Reviews.* Vol. 17, No. 2.

Hook, E.B., and R. R. Regal (1982). Validity of Bernoulli census, log-linear, and truncated binomial models for correcting for underestimates in prevalence studies. *American Journal of Epidemiology*, 116: 168-76.

Hook, E.B., and R. R. Regal (1992). The value of capture-recapture methods even for apparent exhaustive surveys: the need for adjustment for source and ascertainment intersection in attempted complete prevalence studies. *American Journal of Epidemiology*, 135: 1060-7.

Hook, E. B., S. G. Albright, and P. K. Cross (1980). Use of Bernoulli census and log-linear methods for estimating the prevalence of spina bifida in live births and the completeness of vital record reports in New York State. *American Journal of Epidemiology*, 112: 750-8.

Hser, Y. I. (1993) Population estimates of intravenous drug users and HIV infection in Los Angeles County. *International Journal of Epidemiology,* 22, 3: 559-565.

Hser, Y. I. (1993). Population estimates of intravenous drug users and HIV infection in Los Angeles County. *Int. J Addict*, 28: 695-709.

Hser, Y.I. (1993). Population estimation of illicit drug users in Los Angeles County. *J Drug Issues*, 23: 323-34.

Hudson, M.F. (1986) Elder Mistreatment: Current Research. In K. Pillemer and R. Wolf (eds.) *Elder Abuse.* Dover, MA: Auburn House.

Huether, C. A., G. R. Gummere, and E. B. Hook EB, et al (1981). Down's syndrome: percentage reporting on birth certificates and single year maternal age risk rates for Ohio 1970-79: comparison with upstate New York data. *Am J Public Health*, 71: 1367-72.

International Working Group for Disease Monitoring and Forecasting (1995) Capture-Recapture and Multiple-Record Systems Estimation II: Applications in Human Diseases. *American Journal of Epidemiology.* 142(10).

International Working Group for Disease Monitoring and Forecasting (1995) Capture-Recapture and Multiple-Record Systems Estimation II: History and Theoretical Development. *American Journal of Epidemiology.* 142(10).

Johnson, Michael P. (1995) Patriarchal Terrorism and Common Couple Violence: Two Forms of Violence Against Women. *Journal of Marriage and the Family.* 57: 283-294.

Jones, Ann (1994) *Next Time, She'll Be Dead: Battering & How to Stop It.* Beacon Press. Boston.

Kehoe, L., W. Hall, and A. Mant. Estimates of the number of injecting drug users in a defined area. *Aust J Public Health*, 16: 232-7.

King, Gary and Robert Keohane, and Sidney Verba, (1994) Designing Social Inquiry: Scientific Inference in Quantitative Research, Princeton: Princeton University Press, (pp. 29-30).

Kozinetz, C. A., M. L. Skender, and N. MacNaughton, et al (1993). Epidemiology of Rett syndrome: a population based registry. *Pediatrics*, 91: 445-50.

Kuhn, T.S. (1970) *The Structure of Scientific Revolutions.* Chicago: University of Chicago Press.

Kurz, D. (1989). Social science perspectives on wife abuse: Current debates and future directions. *Gender and Society,* 3, 489-505.

LaPorte, R. E., E. S. Tull, and D. McCarty (1992). Monitoring the incidence of myocardial infarctions: applications of capture-mark-recapture technology. *Int. J Epidemiology*, 21: 258-62.

LaPorte, R.E., D. McCarty. G. Bruno, et al (1993). Counting diabetes in the next millennium: application of capture-recapture technology. *Diabetes Care*, 16:528-34.

Levande, Diane (1996) Domestic Elder Abuse Research (DEAR) proposal to the Michigan Department of Community Health and the Centers for Disease Control.

Lewis, C. E., and K. M. Hassanein (1969). The relative effectiveness of different approaches to the surveillance of infections among hospitalized patients. *Med Care*, 7: 379-84.

Lie, R. T., I. Heuch, and L. M. Irgens (1994). Maximum likelihood estimation of the proportion of congenital malformations using double registration systems. *Biometrics*, 50:433-44.

Lincoln, F.C. (1930). Calculating waterfowl abundance on the basis of banking returns. Cir. U.S. Dept Agric. 118, 1-4.

Martin, D. (1981). *Battered Wives*. Volcano, CA: Volcano Press.

Mastro, T.D., D. Kitayaporn, B. G. Weniger, S. Vanichseni, V. Laosunthorn, T. Uneklabh, C. Uneclabh, K. Choopanya, and K. Limpakarnjanarat (1994) Estimating the number of HIV-infected injection drug users in Bangkok: A capture-recapture method. *American Journal of Public Health,* 84(7): 1068-1069.

Mastro, T. D., D. Kitayaporn, and B. G. Weniger, et al (1994). Estimating the number of HIV-infected injection drug users in Bangkok: a capture-recapture method. *Am J Public Health*, 84: 1094-9.

Maxwell, Christopher (1998). *The specific deterrent effect of arrest on aggression between intimates and spouses.* Dissertation Thesis. Rutgers Newark Graduate School.

McCarty, D. J., C. K. Kwoh, and R. E. LaPorte (1992). The importance of incidence registries for connective tissue diseases. (Editorial). *J Rheumatol*, 19: 1-7.

McKeganey, N, M. Barnard, A. Leyland, et al (1992). Female street-working prostitution and HIV infection in Glasgow. *BMJ*, 305: 801-4.

McPherson, B. (1990) *Aging As A Social Problem.* Toronto: Butterworths.

Merton, R.K. (1967) *On theoretical sociology.* New York: The Free Press.

Modesitt, S. K., S. Hulman, and D. Fleming. Evaluation of active versus passive AIDS surveillance in Oregon. *Am J Public Health*, 80: 463-4.

Nanan, Debra J. and Franklin White (1997) Capture-Recapture: Reconnaissance of a Demographic Technique in Epidemiology. *Chronic Diseases in Canada*. Vol. 18, No. 4: 144-148.

Nettler, G. (1978) *Explaining Crime*. 2nd edition, New York: McGraw Hill.

Neugebauer, R. & Wittes, J. (1994) Annotation: Voluntary and involuntary capture-recapture samples - - Problems in the estimation of hidden and elusive population. *American Journal of Public Health*, 84, 7: 1068-1069.

Neugebauer, R (1984). Application of a capture-recapture method (the Bernoulli census) to historical Epidemiology. *American Journal of Epidemiology*, 120:626-34.

Newmeyer, J. A. (1988). The prevalence of drug use in San Francisco in 1987. *J Psychoactive Drugs*, 20: 185-9.

Office of the State Demographer (1996). The Older Population Growth in Michigan in 1995. Michigan Department of Management and Budget. *The Michigan Population Update*, Vol. 4, No. 4. Dec.

Office of the State Demographer (1997). A majority of Michigan's counties continue to grow faster than the national averages of 1996. Michigan Department of Management and Budget. *The Michigan Population Update*, Vol. 5, No. 2. June.

Nourjah, P., D. J. Wright, J.J. Korelitz, CMB Cain, E. C. Wright, L. B. Seeff (1997) An application of Capture-Recapture Methods to Adjust for Incomplete Cases Ascertainment: The Effect of Misclassification Bias. Westat, Inc. Rockville, MD.

Pagelow, MD (1984) *Family Violence*. NY: Praeger.

Palfrey, J. S., M. Haynie, and S. Porter, et al (1994). Prevalence of medical technology assistance among children in Massachusetts in 1987 and 1990. *Public Health Rep*, 109: 226-33.

Pence, Ellen (1996) Coordinated Community Response to Domestic Assault Cases: A Guide for Policy Development. Minnesota Program Development, Inc.

Petersen, C. G. J. (1896) The yearly immigration of young plaice into the Limfjord from the German Sea. Rep. Dan. Biol. Stn (1895) 6, 5-84.

Pillemer, K. and Finkelhor, D. (1988) The Prevalence of Elder Abuse: A Random Sample Survey. *The Gerontologist*, 28 (1) 51-57.

Pillemer, K. (1986) "Risk Factors in Elder Abuse: Results from A Case-Control Study." In K. Pillemer and R. Wolf (eds.) Elder Abuse. Dover, MA: Auburn House.

Pillemer, Karl & Finkelhor, David. (1988) "The Prevalence of Elder Abuse: A Random Sample Survey." The Gerontological Society of America. Vol. 28(1) p.51-57.

Pillemer, Karl A. & Wolf, Rosalie, S. (1993) "Elder Abuse." MA: Auburn House.

Prevdts, D. R., R. W. Sutter, and P. M. Strebel, et al (1994). Completeness of reporting for paralytic poliomyelitis, United States, 1980 through 1991: implications for estimating the risk of vaccine-associated disease. *Arch Pediatric Adolesc Med*, 148: 479-85.

Rosenberg, Mark L. and Mary Ann Fenley (1991). *Violence in America: A Public Health Approach.* Oxford University Press.

Rossi, A. S., and Rossi, P.H. (1990). Of human bonding: Parent-child relationships across the life course. New York: Aldine de Gruyter.

Roy, M. (Ed.). (1976). *Battered Women: A Psycho-social Study of Domestic Violence.* New York: Van Nostrand Reinhold.

Rubin, G, D. Umbach, and S. F. Shyu, et al (1992). Using mark-recapture methodology to estimate the size of a population at risk for sexually transmitted diseases. *Stat Med*, 11: 1533-49.

Sacks. J. J. R. W. Sattin, and S. E. Bonzo (1989). Dog bite-related fatalities from 1979 through 1988. *JAMA*, 262: 1489-92.

Scheff, T. J. (1966) *Being mentally ill.* Chicago, IL: Aldine.

Schouten, W, H. Straatman, L. A. Kiemeney, et al (1994). The capture-recapture method for estimation of cancer registry completeness: a useful tool? *International Journal of Epidemiology*, 23: 1111-16.

Sekar, C. C. and W.E. Deming (1949). On a method of estimating birth and death rates and the extent of registration. *Journal of American Statistical Association.* 44, 101-115.

Serrano Rios, M, C. S. Moy, R. Martin Serrano, et al (1990). Incidence of type 1 (insulin-dependent) diabetes mellitus in subjects 0-14 years of age in the Comunidad of Madrid, Spain. *Diabetologia*, 33: 422-4.

Shryock, Henry. (1976) *The Methods and Materials of Demography.* The Academic Press, San Diego, CA.

Sengstock, M.C. (1991) Sex and Gender Implications in Cases of Elder Abuse. *Journal of Women & Aging,* 3 (2) 25-43.

Stark, Evan and Anne H. Flitcraft. (1991) Spouse Abuse in *Violence in America: A Public Health Approach.* Edited by Mark L. Rosenberg and Mary Ann Fenley. Oxford University Press.

Statistics Canada. (1993) Canadian Centre for Justice Statistics. Violence Against Women Survey. Ottawa, Ontario: Minister of Industry, Science, and Technology.

Stets, J., and D. Henderson (1991) "Contextual Factors Surrounding Conflict Resolution While Dating: Results from a National Study." *Family Relations* 40:29-36.

Straus, M. A. (1971). Some social antecedents of physical punishment: A linkage theory interpretation. *Journal of Marriage and the Family,* 33, 658-663.

Straus, MA, Gelles, R.J., and Steinmetz, S. K. (1980) *Behind Closed Doors: Violence in the American Family.* Garden City, NY: Anchor Books.

Sutter, R. W., S. L. Cochi, and E. W. Brink, et al (1990). Assessment of vital statistics and surveillance data for monitoring tetanus mortality, United States, 1979-1984. *American Journal of Epidemiology*, 131: 132-42.

Sutter, R. W., and S. L. Cochi (1992). Pertussis hospitalizations and mortality in the United States, 1985-1988: evaluation of the completeness of national reporting. *JAMA* 267: 386-91.

Swank, Constance. 1995 Images of Aging in America: Final Report. American Association of Retired Persons, Washington DC

Taylor, R (1989). *Global Programme on AIDS.* A review of methods for estimating the size of subgroups particularly at risk of infection with HIV, and development of proposals which could be used to enumerate these populations in the field. Geneva, Switzerland: World Health Organization.

US Department of Justice (1998) *Violence by Intimates: Analysis of Data on Crimes by Current or Former Spouses, Boyfriends, and Girlfriends.* Office of Justice Programs, Bureau of Justice Statistics, NCJ-167237, March 98.

Utech, M. and Garrett, R. (1992) Elder and Child Abuse. *Journal of Intimate partner Violence,* 7 (3) 418-428.

van Haastrecht, H. J., J. A. van den Hoek, and C. Bardoux, et al (1991). The course of the HIV epidemic among intravenous drug users in Amsterdam, The Netherlands. *Am J Public Health*, 81: 59-62.

Vinton, L. (1992) Battered Women's Shelters and Older Women: The Florida Experience. *Journal of Family Violence,* 7 (1) 63-72.

Vold, G. B. and T.J. Bernard (1985) *Theoretical criminology.* 3rd edition. New York: Oxford Press.

Walker, L.E. (1984) *The Battered Woman Syndrome.* NY: Springer.

Watts, C, A. Zwi, and D. Wilson, et al (1994). Capture-recapture as a tool for program evaluation. (Letter). *BMJ*, 308: 858.

Weis, Joseph G. (1989) Family Violence Research Methodology and Design in *Family Violence, Crime and Justice: A Review of Research.* Volume 11, Edited by Lloyd Oblin and Michael Tonry, pages 117-162.

White, J., and Koss, M. (1991). "Courtship Violence: Incidence in a National Sample of Higher Education Students." *Violence and Victims* 6:247-256.

Wickens, T. D. (1993). Quantitative methods for estimating the size of a drug-using population. *J Drug Issues*, 23: 185-216.

Winton, Chester A. (1995) *Frameworks for Studying Families.* Guilford, Connecticut, The Dushkin Publishing Group, In.

Wittes, J, and V. W. Sidel (1968). A generalization of the simple capture-recapture model with applications to epidemiological research. *Journal of Chronic Diseases*, 21: 287-301.

Wittes, J. T., T. Colton, and V. W. Sidel (1974). Capture-recapture methods for assessing the completeness of case ascertainment when using multiple information sources. *Journal of Chronic Diseases*, 27: 25-36.

Wolf, R. (1986) Major Findings from Three Model Projects on Elder Abuse. In K. Pillemer and R. Wolf (eds.) *Elder Abuse.* Dover, MA: Auburn House.

Wolf, Rosalie & Pillemer, K. (1984) "What's New in Elder Abuse Programming?" The Gerontologist. Vol. 34(1) p.126-129.

Woodward, J. A., D. G. Bonett, and M. L. Brecht (1985). Estimating the size of a heroin-abusing population using multiple-recapture census. *NIDA Res. Monogr*, 57: 158-71.

Yllo, K. and Bogard, M. (1988) *Feminist Perspectives on Wife Abuse.* Newbury Park, CA: Sage.

York, J. C., and D. Madigan. *Bayesian methods for estimating the size of a closed population.* Technical report no. 234. Seattle, WA: Department of Statistics, University of Washington.

Zastrow, Charles (1992) *Social Problems: Issues and Solutions.* (3rd Ed.) Nelson-Hall Publishers, Chicago, IL.