An Improved Methodology for Analyzing Age-Arrest Profiles: An Application to a Western Australian Offender Population

by

Richard W Harding and Ross A Maller

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An Improved Methodology for Analyzing Age–Arrest Profiles: Application to a Western Australian Offender Population

Richard W. Harding[1] and Ross A. Maller[1,2]

A new methodology for displaying and analyzing "arrest profiles" of a population of offenders is illustrated on a data set containing information on all arrests made in the jurisdiction of the state of Western Australia in the 12-year period 1 April 1984 to 31 December 1995. The arrest profile shows the number of arrests accumulated by an individual offender as a function of the age at which each arrest took place. This provides a summary of the "arrest careers" of the individuals in the population and facilitates comparisons between groups of interest in the population, such as sex and race groups. In particular, it enables comparisons to be made between cohorts of offenders defined by the age-at-onset of their offending. For the Western Australian population analyzed here we find large differences between sex and race (Aboriginal or non-Aboriginal) groups, and also between age-at-onset cohorts, and we place these differences in the context of current criminological discussions which posit that higher mean numbers of offenses will be committed by early career starters.

KEY WORDS: age–arrest profiles; criminal careers; recidivism; age-at-onset of offending.

1. CRIMINAL JUSTICE POLICY AND CRIMINAL CAREERS RESEARCH

By emphasizing incapacitation, much contemporary criminal justice policy seems increasingly to be underpinned by assumptions as to the likely future escalation of individual criminal careers. The 1990s trend toward "three strikes" and similar laws, applicable mostly to adult offenders but in some jurisdictions also to juveniles, has habitually been defended on the basis that chronic offenders will be incapacitated by incarceration and thereby

[1]Crime Research Centre, University of Western Australia, Nedlands 6907, Western Australia.
[2]Department of Mathematics, University of Western Australia, Nedlands 6907, Western Australia.

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prevented from committing an always imprecise (but invariably large) number of future crimes.

Criminal careers research enables some scientific analysis to be made of the appropriateness and efficacy of such policies and also informs discussion of some theoretical issues relating to criminality, as well as other practical matters. In relation to juveniles, a key issue is the age-at-onset of offending and its relationship to both the frequency and the intensity of subsequent criminal justice system contacts. Other issues include (i) age-at-onset and its relationship to the qualitative seriousness of the subsequent criminal career; (ii) the sequence of onsets of various types of offending; (iii) subgroup, particularly race, overlays to each of these matters; and (iv) crossover patterns between juvenile and adult criminal careers. Reliable ways of modeling such matters would certainly inform debate upon incapacitation approaches to crime control.

Much of the groundbreaking work in this area (Christie, 1960; Sellin and Wolfgang, 1964; Wolfgang *et al.*, 1972; Farrington, 1981; Tracy *et al.*, 1994; Farrington, 1994) has arisen out of cohort studies of offenders and nonoffenders. In selecting a total cohort, these researchers enabled themselves to pursue questions as to the differences between offenders and nonoffenders, social/environmental aspects of offending patterns, and so on. The purest available methodology for this kind of study is prospective longitudinal; but this of course possesses numerous drawbacks, not least the passage of time required before the cohort has aged sufficiently for data relevant to the key issues to start becoming meaningful. Consequently, the more favored methodology has become that of the creation of a retrospective or historical cohort and the tracing of its subsequent development. From the point of view of exploring the nature of criminal careers and the patterns of offending, the drawback to this approach is simply that the population of offenders within a total birth cohort of offenders and nonoffenders is inevitably going to be quite small, unless the cohort itself was very large—in turn posing management problems relating to lost data, filtering, and the like.

An alternative methodology, from the point of view of criminal careers issues, would seem to be to examine a total population of offenders, as opposed to a restricted subset of the general (offender/nonoffender) population. In the present research, therefore, we isolate a particular dimension of a criminal career—arrest histories of offenders—and suggest a different way of exploring the sorts of criminological and criminal justice issues addressed above.

Of course, this approach requires that a comprehensive and reliable retrospective database should exist—a luxury not often available to criminological researchers and certainly not to the authors of the pioneering studies

referred to above. Fortunately, in Western Australia such a database now exists: see Section 3. We have been able to fortify analysis of these data by importing "survival analysis" techniques developed earlier by Broadhurst and Maller (1990a, b, 1991a, b, 1992; Broadhurst *et al.*, 1988; see also Maller and Zhou 1996). These techniques enable "censored" or incomplete data to be managed in a methodologically appropriate way.

Integral to our approach is a means of displaying our findings in a novel and informative manner, thereby facilitating the analysis and understanding of arrest careers. Accordingly, this paper describes a new method of presenting and analyzing the arrest profiles of a population of offenders. By an "arrest profile" we mean the number of arrests accumulated by an individual as a function of the age at which each arrest took place. By collecting together the arrest careers of all offenders in a population and "averaging" them, we obtain a summary of the arrest history of the population as it relates to the ages of offenders. However, the "averaging" process must properly take into the longitudinal, censored nature of the data if we are to produce an estimator with good statistical properties.

The method we present in the next section is of general applicability, although in practice it is most useful and informative when applied to offenders whose arrest careers begin at similar ages. In this context, because in the Western Australian jurisdiction the majority of arrest careers commence as juveniles, the main focus of our discussion is arrest of juveniles, even though the population of offenders examined here relates to all offenders, of whatever age, who commenced their arrest careers in Western Australia between 1 April 1984 and 31 December 1995.

It is well understood, of course, that a "criminal career' in the broader sense is in actuality the result of an extremely complex interaction of cultural, social, legalistic, psychological, and administrative factors, each in turn affected by accidents of time and place. These factors, furthermore, operate differentially in relation to individuals on the multitude of events which go to make up a "criminal career"—events which range from minor contacts such as informal police cautions right through to criminal charges, convictions, and imprisonment. The various permutations and combinations of these processes can operate in apparently random and unpredictable ways. Thus, nonoffenders may be arrested or the innocent found guilty; conversely, offenders may frequently remain undetected, either generally or in relation to one or more of their offenses, or the guilty may be acquitted. Also, some "careers" may desist at the first caution or the first arrest or the first imprisonment, while others will persist to a much later stage.

According to the aims of the particular project, the criminal careers researcher can quite appropriately select any of the various markers which are available—from cautions to imprisonment. We have selected arrest

events because they can be defined and identified in an unequivocal way and consequently possess the basic scientific property of reproducibility of results. A better understanding of arrest careers bears directly upon the set of criminological questions with which we are concerned here—the relationship of age-at-onset to the frequency, intensity, duration, and seriousness of the subsequent career; the sequence of onsets; the related question of whether "three strikes" and similar laws target persons whose subsequent careers are likely to be dangerous to the community; conversely, the impact of diversionary strategies; and so on.

It should be noted that we focus primarily upon offenders' *actual* ages at the time of offending. Thus, by an "arrest profile" we mean the numbers of arrests accumulated by an offender as a function of his/her actual age. However, as a check on the robustness of our method, we take account of the possibility that the profiles might be affected by the inclusion of "nonstreet time"—i.e., time during which an offender is not exposed to the risk of arrest as a result of being in prison or lockup—by presenting below one analysis in which we adjust each offender's age for time spent in prison or lockup, if any. This is done by subtracting the detention time whenever it occurs in the offender's record from the offender's age to give the offender's "street-age." As we show, for our data set this mode of calculation produces age–arrest profiles, for the subgroups we consider, which are virtually identical to those not adjusted for nonstreet time. Consequently, we concentrate here on (actual) age at arrest profiles, which we believe, anyway, are a more natural and informative measure.

However, even the simplification of restricting our attention to arrest careers (ignoring reduced exposure time) leaves us with a number of difficult statistical issues to consider. Methods of analysis of data which are "censored"—due to the fact, in our case, that individual careers cannot be followed up beyond the cutoff date (31 December 1995)—are still under vigorous development in the statistical literature. Moreover, the application of these methods to criminological data such as ours raises special problems which have been addressed in detail only in recent years. Chief among these problems is the fact that offenders may (or may appear to) desist entirely from offending at some point. Recognition of this fact has led to a new body of research (Maller and Zhou, 1996) needed to cope with these issues. That research has so far concentrated mainly on a single event time—the time till the first rearrest following a specified arrest—whereas to examine an arrest career we must consider the whole series of rearrests. It is this new methodological development, required to deal with the longitudinal, censored nature of the series of arrest events, which is briefly formulated in this paper and illustrated in some detail in relation to the Western Australia data.

2. METHODOLOGY

What we call an "arrest profile" of an individual is known in statistical theory as an observation on a "counting process." This simply means that, for the observed data, we count the number of arrests of an individual, noting the ages at which they occur, and think of the profile as being the number of arrests accumulated by the individual as a function of age. As an illustrative example, Table I sets out the data for the observed arrest profiles of two individuals. Thus Individual 1 was first arrested in mid-1995, at the age of 18.57 years, and no subsequent arrest was observed within the limit of the follow-up (which ceased at 31 December 1995), at which time Individual 1 was 19.23 years of age. The latter observation constitutes a censored or incomplete observation on the age at the second arrest (if it ever occurs). The censored observation is denoted by a superscript asterisk in Table I. Individual 2, first arrested in 1984, has a more extensive record, consisting of three arrests at the ages of 25.32, 28.92, and 32.93 years, as at the cessation of follow-up on 31 December 1995 (without having incurred a fourth arrest). Once more, the final or censored observation is denoted by an asterisk. Clearly, any entry listed in a table such as Table I will conclude with a censored observation.

Our data analysis proceeds by way of extracting from the database the information contained in Table I for all individuals in the group we wish to analyze and then estimating the "expected" profile by "averaging" over the individual profiles. This averaging process is not straightforward, however, as we must allow for the possible bias introduced by the censoring.

The analysis of counting processes is well developed in the statistical literature but, as far as we know, has not been applied to arrest profiles such as we do here. Furthermore, standard statistical methods of dealing with such data are designed for cases in which the "point process" of events (the arrests) essentially continues forever, and observation of it is limited only by the necessity to define a cutoff time of analysis of the data. [See, e.g., Lawless (1982) for a discussion of the standard methods in a noncriminological context.] But we know from extensive research (summarized by Broadhurst and Loh, 1995), that, with relatively high probabilities, offenders' "careers" may cease after just one arrest or, having accumulated two

Table I. Examples of Individuals' Arrest Profiles

Individual No.	No. of arrests before 31 Dec. 1995	Age (years) at arrest number			
		1	2	3	4
1	1	18.57	19.23*		
2	4	25.32	28.92	32.93	36.43*

arrests, may cease before the third, and so on (see, e.g., Broadhurst and Loh, 1995, Table V). Research by Maller and Zhou (1992) into the statistical characteristics of data containing individuals who will not recidivate suggests a new kind of estimator. The definition and properties of the new estimator are discussed in detail by Maller and Zhou (1997), but we give a brief summary here, sufficient to allow practitioners to calculate the estimator and to assess its precision for themselves.

To understand the construction of our proposed estimator, we need some notation. Suppose there are n individuals in the group under consideration and let $n_i(t)$ be the arrest profile associated with Individual i, $1 \le i \le n$. We can envisage plotting information such as that given in Table I for every individual in the group as a step function which increases by 1 (arrest) at the age at which the arrest occurs. We then wish to "average" the resulting functions in some way to produce an estimate of the expected profile. The mathematical formulation of our method of doing so is as follows. Let $N(t)$ be the random function of t on which the individual profiles represent independent and identically distributed observations. Let T_j be the random variable representing the age at the jth arrest, censored if this has not occurred by the limit of the follow-up. The following simple probability calculation suggests the estimator we use. The expected value of $N(t)$ can be written, using a standard identity, as

$$E(N(t)) = \sum_{j \ge 1} jP\{N(t) = j\} = \sum_{j \ge 1} P\{N(t) \ge j\}$$

and we also note that the event $\{N(t) \ge j\}$ occurs if and only if $\{T_j \le t\}$. (Equivalently, j or more arrests have been accumulated on or before age t if and only if the time of occurrence of the jth arrest is before t). Thus we have

$$E(N(t)) = \sum_{j \ge 1} P\{T_j \le t\} \tag{1}$$

This equation suggests constructing an estimator of $E(N(t))$ by estimating separately the cumulative distributions of the T_j, then adding them up.

This idea forms the basis of our procedure. One complication is that the observations on the T_j are potentially censored ones (except for T_1; we observe the age at first arrest for all individuals in the database). Consequently, as an estimator of the cumulative distribution function of the T_j, we use the well-known Kaplan–Meier estimator (KME), except for T_1, for which we use the empirical distribution function estimator, the EDF. Kalbfleisch and Prentice (1980) give formulae for calculating the KME, and Shorack and Wellner (1986) discuss the EDF. Thus, letting $\hat{F}_{jn}(t)$ denote the KME of the age at the jth arrest, $j = 2, 3, \ldots$, with $\hat{F}_{1n}(t)$ the EDF of

the age at the first arrest, our proposed estimator of $E(N(t))$ can be written simply as

$$\hat{E}_{KM}(t) = \sum_{j \geq 1} \hat{F}_{jn}(t) \tag{2}$$

This estimator can easily be calculated from age-at-arrest data using standard formulae. Note that we are not assuming that the distributions of the T_j (other than that of T_1) are proper or have total mass equal to 1; we do not expect all individuals necessarily to accumulate a second arrest after the first or, having incurred a second arrest, necessarily to accumulate a third, and so on. This feature is reflected in the fact that the KME of the age at the jth arrest, where $j \geq 2$, typically levels off at a value less than 1, as in the figures of Broadhurst and Loh (1995).

The KME possesses certain desirable properties as an estimator of the unknown distribution of the age at the jth arrest. Provided follow-up is sufficient, in a sense which is quantified by Maller and Zhou (1992), the KME is asymptotically unbiased, consistent, and normally distributed in large samples. Due to the additive construction of the estimator in (2), these properties will be transferred to our proposed estimator of $E(N(t))$, as verified by Maller and Zhou (1997). An assessment of the precision of estimation of $E(N(t))$ can also be made (see the Appendix) and is illustrated in the figures.

The estimator in (2) can be calculated for any subgroup of individuals in a population, and we are concerned in particular with groups divided by gender and race (Aboriginal and non-Aboriginal), which are known to be significant in the Western Australian prison population. Another important subgrouping of the data we analyze is by cohorts of offenders whose arrest careers begin at, or about, the same age. For example, we can estimate the arrest profiles for those whose first arrest occurred between 5 and 15 years of age, or between 15 and 30 years, etc. In fact the magnitude of the database, discussed in the next section, is such that we are able to analyze some age cohorts on a much finer scale, of individual years. This kind of analysis provides the most informative and useful arrest profiles.

3. DATA

The data drawn upon in this report include information on all arrests made by the Western Australian Police Service in the (approximately) 12-year period 1 April 1984 to 31 December 1995. Since 1 January 1990 these arrest data have been routinely collected from the police by the Crime Research Centre at the University of Western Australia, and data for the earlier 6 years had been especially collected for the purposes of the criminal

Table II. Arrest Characteristics by Sex and Race

	Male		Female	
	Aborigine	Non-Aborigine	Aborigine	Non-Aborigine
Number of individuals	6,776	121,240	4,377	38,961
Average No. of arrests	8.16	2.29	4.57	1.56
Average age at first arrest	19.7	26.7	21.9	28.3
Maximum No. of arrests	107	96	77	95

career research of Maller *et al.* (Broadhurst and Maller, 1992; Broadhurst and Loh, 1995).

The data relate to arrest events, rather than charges, and include proceedings commenced by way of summons as well as actual physical apprehension. Police contacts which fall short of "arrest" are not included here. (These relate to such matters as the cautioning of juveniles and citations in relation to minor traffic offenses.) Where an "arrest" was for more than one alleged offense or charge, it is counted only once. The most serious alleged offense, identified on the basis of the Crime Research Centre's seriousness index (Ferrante *et al.*, 1993), is the one attached to the particular arrest event. So as to examine arrest careers from their inception, we retain in the data only those individuals whose first arrest (ever) occurred in the 11-year period of observation, 1 April 1984 to 31 December 1995.

The total numbers of individuals in the basic sex–race groups, together with the average age of an individual at his/her first arrest, and the average and maximum numbers of arrests accumulated by these individuals up to the cutoff date of 31 December 1995, are given in Table II. Table II shows that the numbers of individuals under study are extremely large by comparison with most data sets available in this area. Histograms of the ages at first arrest for the sex–race groups, in Fig. 1, show highly skewed distributions, with most first arrests occurring before the age of about 20 in the case of Aborigines but with most occurring after the age of about 25 in the case of non-Aborigines.

4. OVERALL ARREST PROFILES

A notable advantage of our methodology is that it enables a clear visual display of the average arrest profile of the individuals of the focal group. Figure 2 shows the arrest profiles of four categories of arrestees: male Aborigines, female Aborigines, male non-Aborigines, and female non-Aborigines. An approximate (conservative) 95% confidence interval (CI) (calculated using the formula in the Appendix) is shown around each profile in Fig. 2, and as expected for such large numbers of observations, the precision of

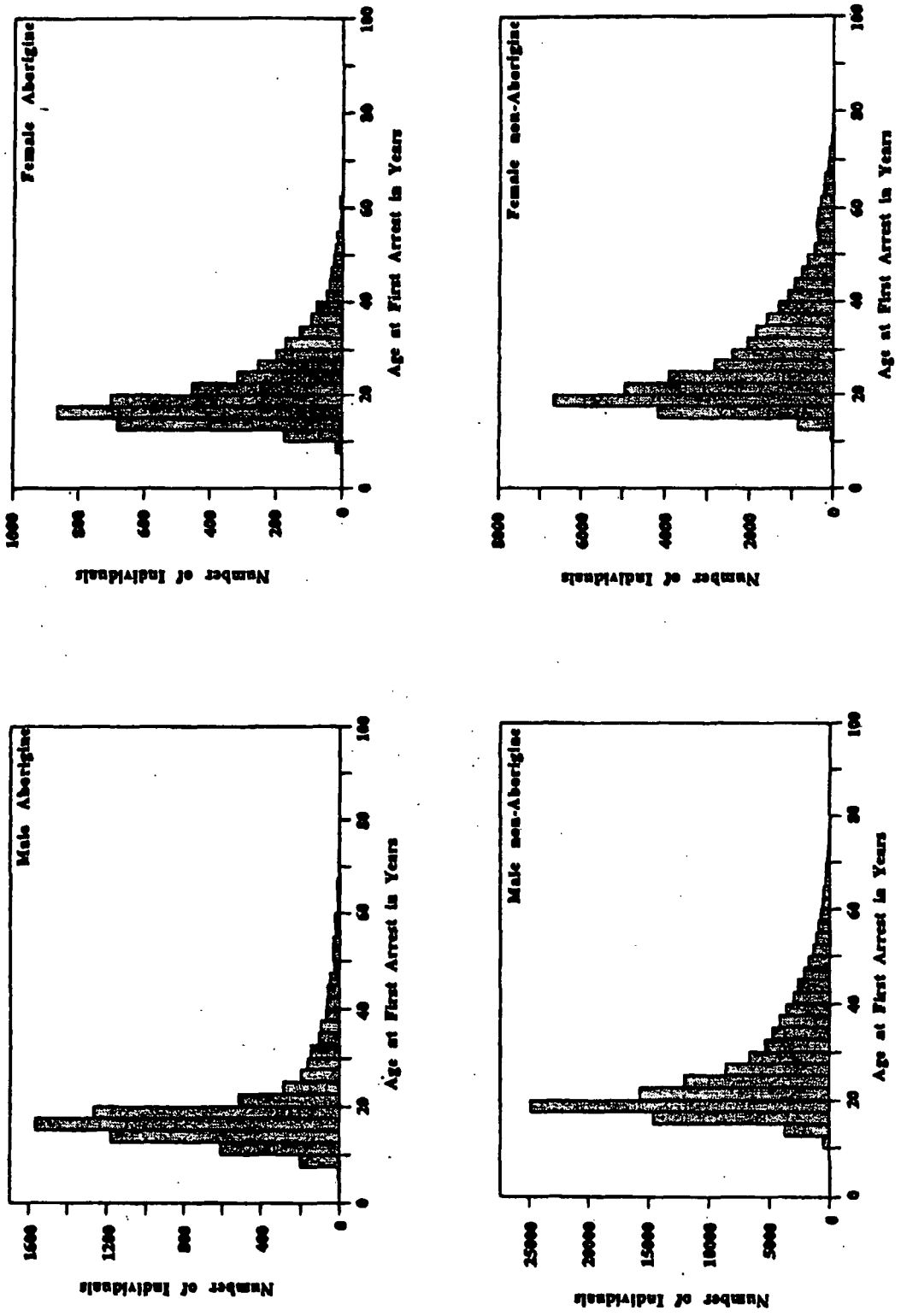

Fig. 1. Distribution of ages at first arrest by sex and race.

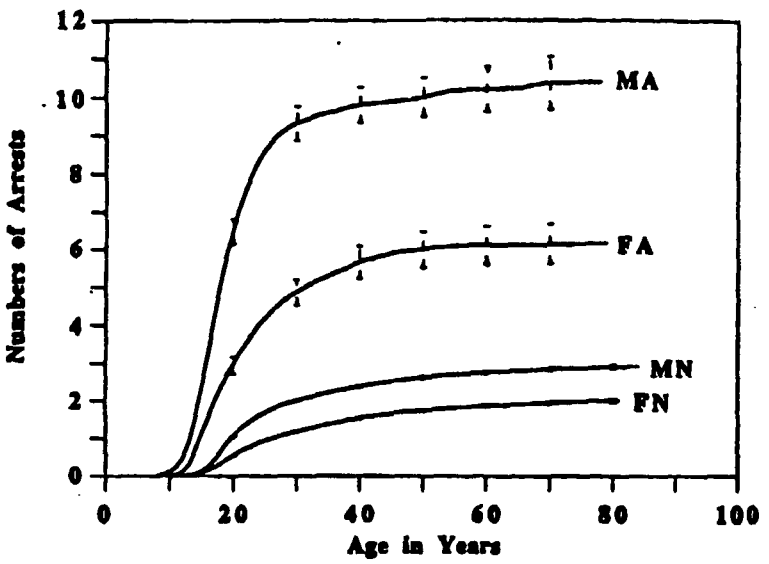

Fig. 2. Estimated arrest profiles by sex and race. MA, male Aborigine; MN, male non-Aborigine; FA, female Aborigine; FN, female non-Aborigine.

estimation of the profiles is very high. Figure 2 shows clearly that ages-at-onset of arrest careers differ markedly between race and sex groups. In particular, careers for Aboriginal males commence as early as 7 years of age (in fact the youngest arrestee in the database was a male Aboriginal boy aged 6.99 years at his first arrest), and arrest careers for male and female Aborigines rise much more sharply than for non-Aborigines. These differences are statistically significant, as the confidence intervals on the figure show.

In addition, Fig. 2 gives an indication of the lifetime numbers of arrests expected to be accumulated by individuals in the database. The curves in the figure level off at values of approximately 10.4 for Aboriginal males, 6.1 for Aboriginal females, 2.9 for non-Aboriginal males, and 2.0 for non-Aboriginal females. Naturally, these estimates are higher than the observed average numbers of arrests in these categories, as given in Table II; this is because of the effect of the censoring—the restricted follow-up available in the database. Approximate 95% CIs for the lifetime estimates are given in Fig. 2.

The profiles have been averaged over the age at first arrest of individuals in Fig. 2, so as to emphasize the major differences in the shapes of the curves between the sex–race groups, and the clear differences between them as they describe juvenile offending, i.e., for offenders under or around the age of 20 years. It should be emphasized once more that the approach embodied in Fig. 2 and all subsequent figures is not directed at differential arrest prevalence between groups but at arrest incidence for those who fall within the arrest population.

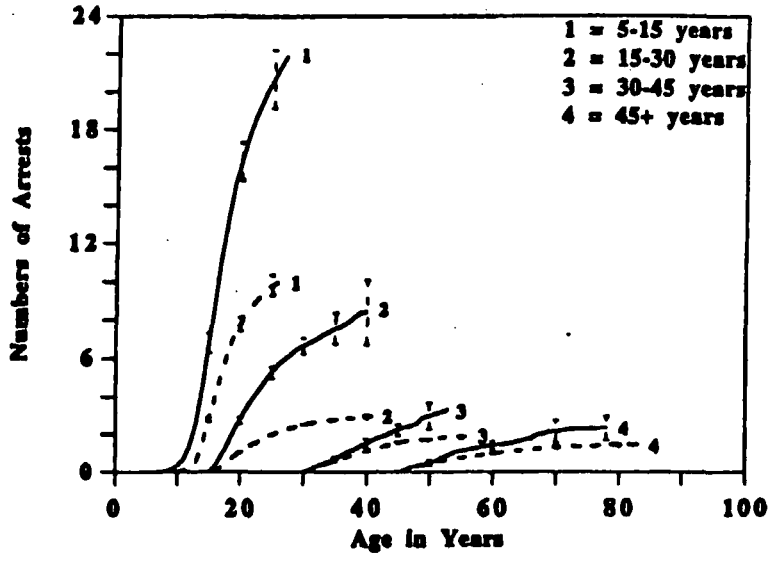

Fig. 3. Estimated arrest profiles by age group and race. Solid line, male Aborigine; dashed line, male non-Aborigine.

Figure 2 gives only an all-offense, "average" arrest profile. However, we expect offenders' "careers" to differ with respect to the ages at which the first arrest was made. Thus, Fig. 3 (males of both race types) and Fig. 4 (females of both race types) break down and visually display the broad pattern represented in Fig. 2 according to the age ranges of the offenders at the times of their first arrests. It can be seen that the expected arrest profiles of all four race/sex subdivisions appear to be crucially affected by age at commencement. The most striking observations are that the arrest profiles

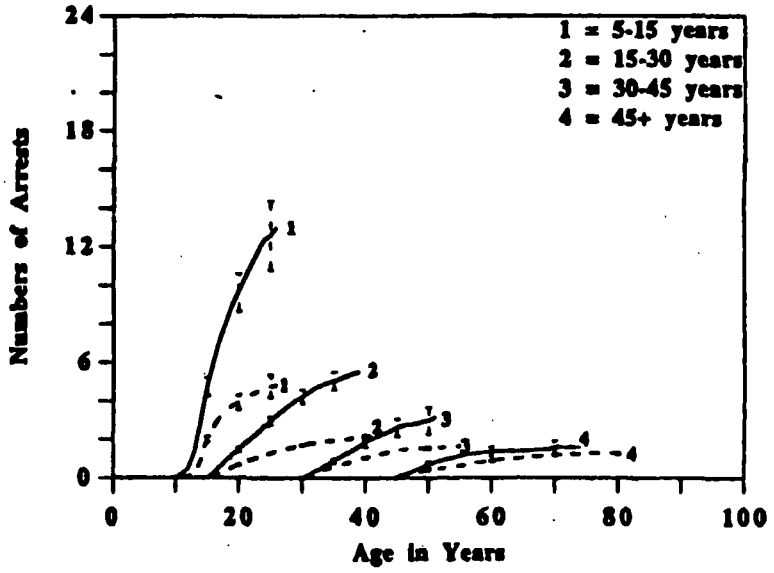

Fig. 4. Estimated arrest profiles by age group and race. Solid line, female Aborigine; dashed line, female non-Aborigine.

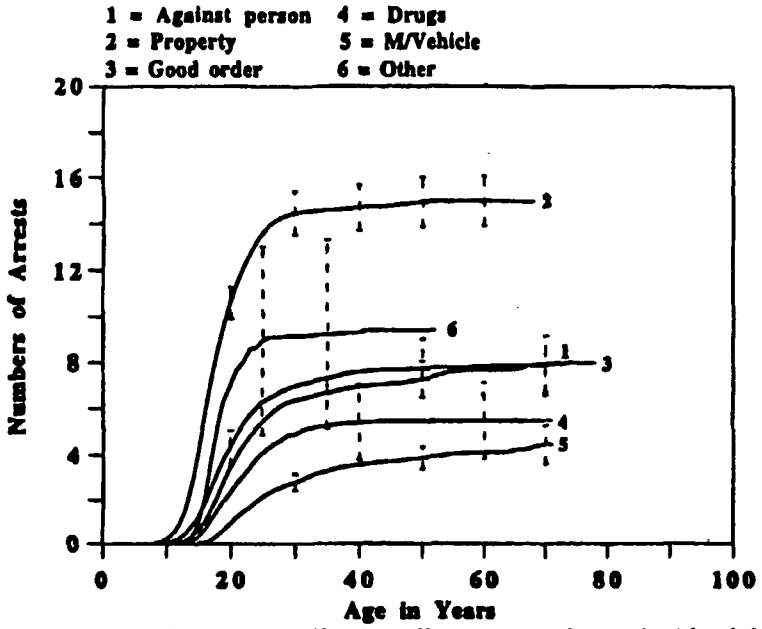

Fig. 5. Estimated arrest profiles by offense group for male Aborigine.

of male Aboriginal offenders begin at around 7 years of age and that male Aborigines whose first arrest occurred at between 5 and 15 years of age can expect on average to have been arrested around 20 times by the age of 22.

The differences between Aboriginal and non-Aboriginal offending patterns are also clearly displayed in Figs. 3 and 4, and these differences are statistically significant, as can be judged by the confidence intervals shown in the figures. At the other end of the scale, it can be seen for all race/sex categories that a first arrest at the age of 45 or more does not seem to herald the commencement of a vigorous new criminal career so much as to reflect relatively isolated and nonrecurring events. Note that the extent of follow-up available in the database—currently a maximum of about 12 years for any offender—is also clearly revealed in Figs. 3 and 4. This amount of follow-up will increase as time goes by and the database is periodically updated.

In Fig. 5 the data are categorized according to the offence type of first arrest. What are displayed, in relation to male Aborigines, are the lifetime expected arrest profiles of arrests for all offense types by offense type of the first arrest. Thus it can be seen, for example, that a male Aborigine whose first arrest is for a property offense has a profile for which about 15 lifetime arrests are expected, whereas one whose first arrest is for an offense against the person has an expected "career lifetime" number of only about 8 subsequent arrests.

Comparable figures may, of course, be constructed in relation to each of the race/sex groups. In principle, this sort of information can also be presented by cohorts of age groups, as well as by homologous and non-homologous offense, i.e., property offense "careers," violence "careers,"

drug "careers," and so on. These data could also be presented so as to show the sequence of onsets of differing offence types. This would shed a different light on the question of the impact of age-at-onset upon subsequent criminal careers and would bear directly upon discussion of possible intervention strategies. However, since our main aim here is only to introduce and illustrate the methods, we leave such detailed data analysis for a more specific report. In the next section we simply use the methodology to compare general juvenile arrest careers with respect to their ages-at-onset.

5. ARREST PROFILES FOR JUVENILES

A major focus of criminological research has been the age-at-onset of criminal offending and its relationship to the frequency, intensity, and seriousness of subsequent criminal justice system contacts. Tracy *et al.* (1990, p. 188) posit, from their two-cohort study, that "the earlier the age-at-onset, the higher the mean number of offences committed [during juvenility], owing to the potential for a longer career among the early starters." The obverse of this is Farrington's observation (1994, p. 526), on the basis of his various studies, that "the duration of criminal careers decreases with increasing age of onset."

In order to examine these hypotheses, we separated out of the data those offenders whose arrest careers commenced at 12, 14, or 16 years of age. (More specifically, we collected together those whose first arrest occurred between 11.5 and 12.5, 13.5 and 14.5, and 15.5 and 16.5 years of age). We retain the classifications of race and sex, for we already know, and the above analyses confirm, that there are large differences in arrest profiles between these groups. The corresponding profiles are tabulated in Tables III and IV. The second column in each of these tables shows the subsequent offending profiles for those first arrested at age 12 years. Similar profiles for those first arrested at ages 14 and 16 years are given in columns 4 and 7 in Tables III and IV. The expected numbers of arrests diminish significantly as the age at first arrest (age at onset) increases, lending marked support to the observation of Tracy *et al.* (1990).

We can also use arrest profiles to examine the intensity of offending across those ages when juvenile offending generally is at its most frequent. In other words, we can investigate how the age-at-onset of offending relates to the expected arrest profile during those difficult teenage years when both prevalence and incidence are at their highest. Tables III and IV also attempt to address that question. We show there the 12 year olds' post-14 profiles (in column 3), by which we mean the arrest careers subsequent to age 14 for those whose first arrest was at 12 years of age and, similarly, the post-16 profiles for those same offenders (in column 5). Likewise, we show the

Table III. Estimated Arrest Profiles by Race for Males

Age	1st arrest at 12	Post 14		Post 16		
		1st arrest at 12	1st arrest at 14	1st arrest at 12	1st arrest at 14	1st arrest at 16
			Aborigine			
12	1.9					
13	3.8					
14	6.4					
15	9.2	3.1	2.2			
16	11.7	5.9	4.4			
17	14.1	8.6	6.6	2.9	2.3	1.7
18	16.2	10.9	8.6	5.2	4.5	3.3
19	18.2	13.2	10.3	7.5	6.3	4.6
20	19.7	14.9	11.5	9.2	7.6	5.8
21	21.1	16.5	12.6	10.9	8.7	6.9
22	22.3	17.7	13.6	12.0	9.8	8.0
23	23.2	18.6	14.5	12.9	10.8	9.1
24	23.3	18.7	15.4	13.0	11.7	10.0
25			16.1		12.5	10.8
26			16.5		12.9	11.6
27						12.3
28						12.6
			Non-Aborigine			
12	1.4					
13	2.3					
14	3.4					
15	4.9	1.9	1.4			
16	6.6	4.1	2.9			
17	8.1	5.9	4.2	2.2	1.5	1.1
18	9.4	7.6	5.6	4.1	3.0	2.1
19	10.7	9.1	6.6	5.8	4.1	2.8
20	11.5	10.2	7.4	6.9	5.0	3.4
21	12.3	11.1	8.1	7.8	5.7	4.0
22	13.2	12.2	8.6	8.9	6.3	4.3
23	13.6	12.7	9.1	9.4	6.8	4.6
24			9.5		7.3	5.0
25			9.8		7.6	5.2
26			9.9		7.7	5.5
27						5.7
28						5.7

post-16 profiles for those whose first arrest was at 14 years of age in column 6 in the tables. These numbers are also plotted in various ways in Figs. 6 through 11.

It is readily apparent that the post-14 and the post-16 expected arrest profiles of those whose first arrest occurred at age 12 are (apart from female

Table IV. Estimated Arrest Profiles by Race for Females

Age	1st arrest at 12	Post 14		Post 16		
		1st arrest at 12	1st arrest at 14	1st arrest at 12	1st arrest at 14	1st arrest at 16
			Aborigine			
12	1.6					
13	3.8					
14	5.8					
15	7.7	2.5	2.2			
16	9.1	4.4	3.9			
17	10.3	5.8	5.3	1.7	1.6	1.2
18	11.5	7.2	6.4	3.3	3.0	2.2
19	12.3	8.2	7.3	4.4	4.1	3.0
20	13.0	9.0	8.3	5.3	5.2	3.6
21	13.9	10.0	9.0	6.6	6.0	4.2
22	14.5	10.7	9.9	7.4	7.0	4.8
23	15.1	11.2	10.4	8.0	8.2	5.4
24			10.9		8.5	6.1
25			11.2		10.0	6.8
26			12.8			7.1
27						7.9
			Non-Aborigine			
12	1.2					
13	1.8					
14	2.2					
15	3.2	2.0	1.2			
16	3.5	2.5	1.9			
17	3.7	2.7	2.5	0.4	0.9	0.8
18	3.8	3.0	3.2	0.8	1.8	1.4
19	4.2	3.7	3.8	1.5	2.6	1.8
20	4.2	3.9	4.1	1.8	3.0	2.1
21	4.4	4.1	4.5	2.2	3.6	2.4
22	4.6	4.3	4.9	2.7	4.8	2.6
23	4.7		5.2		5.1	2.8
24			5.4		5.4	3.0
25			5.7			3.1
26			5.9			3.2
27						3.3

non-Aborigines) higher than for those arrested for the first time at age 14 and 16 years, respectively. Similarly, Figs. 8 and 9 give the comparison between the post-16 expected arrest profiles of those whose first arrest occurred at age 12 and the profiles of those arrested for the first time at age 16, while Figs. 10 and 11 compare the post-16 expected arrest profiles of those whose first arrest occurred at age 14 and the profiles of those arrested for the first time at age 16. The same differences are apparent in these, though

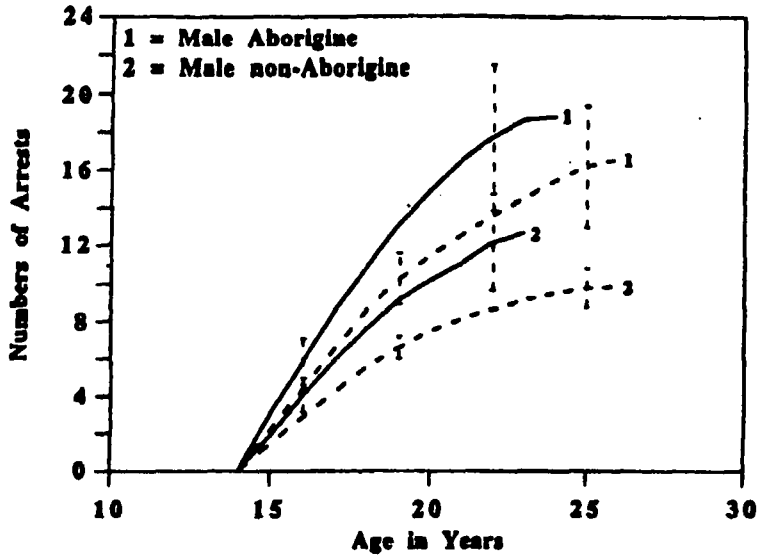

Fig. 6. Estimated arrest profiles by race for male. Solid line—first arrest at 12, career post 14 years; dashed line—first arrest at 14 years.

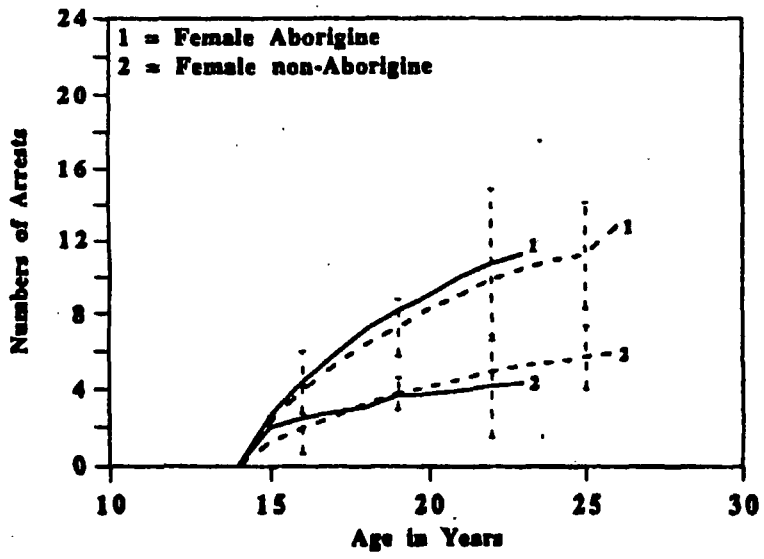

Fig. 7. Estimated arrest profiles by race for female. Solid line—first arrest at 12, career post 14 years; dashed line—first arrest at 14 years.

their magnitudes are not as great. As the figures also show, the methodology utilized here enables the criminal career to be projected beyond juvenility into the mid-twenties, again supporting the observation of Tracy *et al.* (1990). (The database is not yet long enough to enable the profiles to be calculated beyond that point, but this will change as it is updated.)

As for seriousness, Tracy *et al.* (1990, p. 192) state, with regard to their cohorts, that "there is almost no relationship between age-at-onset and

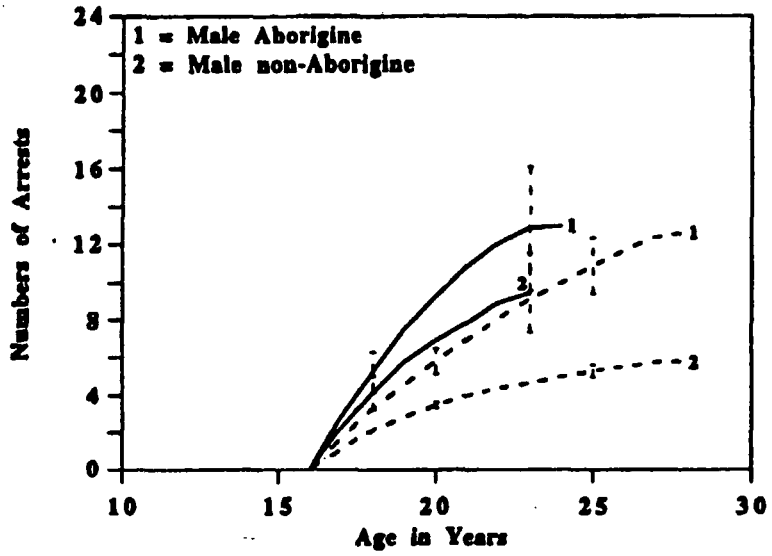

Fig. 8. Estimated arrest profiles by race for male. Solid line—first arrest at 12, career post 16 years; dashed line—first arrest at 16 years.

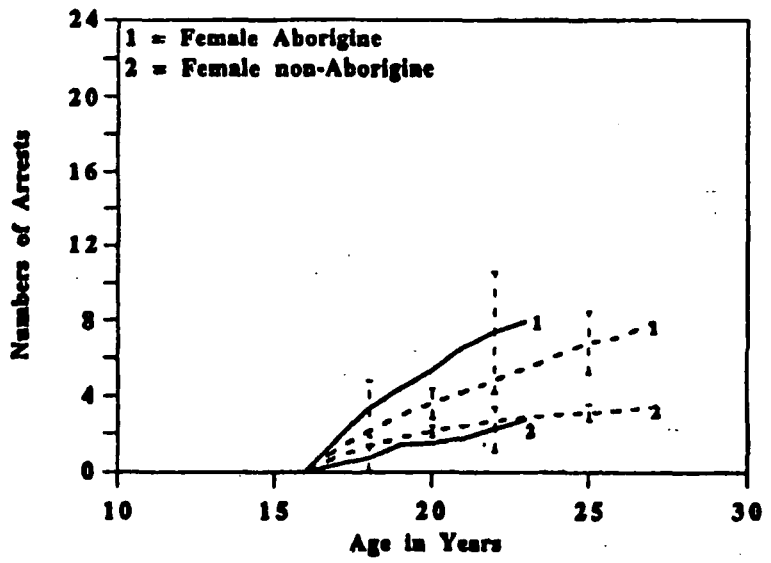

Fig. 9. Estimated arrest profiles by race for female. Solid line—first arrest at 12, career post 16 years; dashed line—first arrest at 16 years.

average career severity." This is an issue which overlaps but is not coextensive with that of the sequence of onsets. We have not investigated that question at this stage; but using the methodology described here, it would be possible, by building upon the analysis displayed in Fig. 5, to test this proposition in relation to total offending populations. However, such an extensive investigation is beyond the scope of this report.

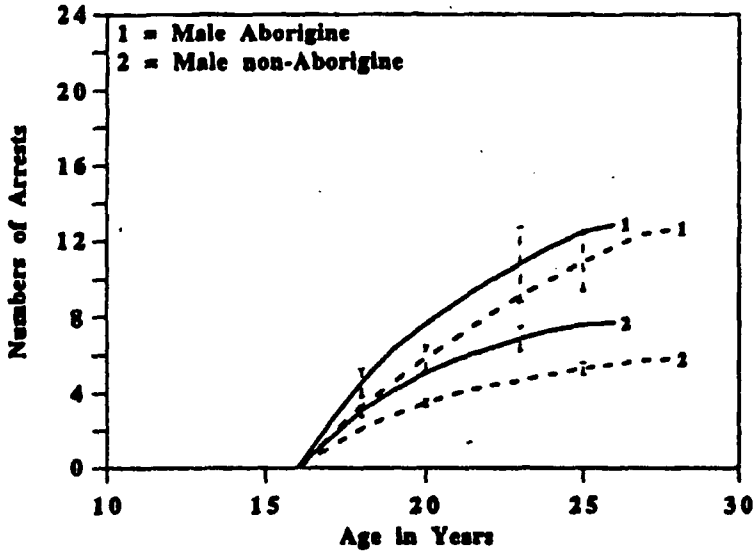

Fig. 10. Estimated arrest profiles by race for male. Solid line—first arrest at 14, career post 16 years; dashed line—first arrest at 16 years.

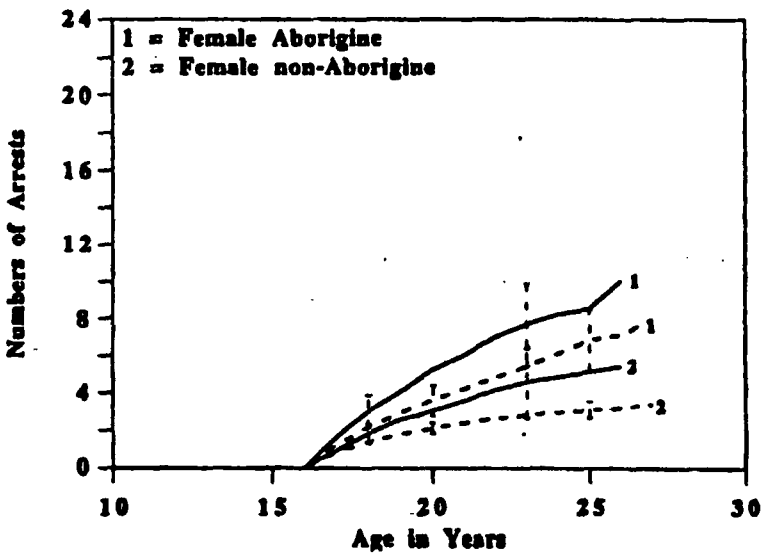

Fig. 11. Estimated arrest profiles by race for female. Solid line—first arrest at 14, career post 16 years; dashed line—first arrest at 16 years.

6. ADJUSTING FOR NONSTREET TIME

If we subtract from each offender's age any time spent in prison or lockup, which is thus time during which the individual is not at risk of rearrest, we obtain his/her "street-age." Although this measure reflects more accurately the offender's accumulated exposure to criminality, we argued in Section 1 that we believe the actual age to be, for the most part, a more meaningful measure against which to calculate a profile of arrests. Nevertheless, in some circumstances a "street-age profile" of arrests might be useful.

Table V. Distribution of Nonstreet Time for Male Aborigines

Between arrests	Percentage with some prison or lockup time	Total amount of prison or lockup time (months)				
		% <6	% 6–12	% 12–24	% 24–36	% 36+
1–2	3.8	95.7	3.2	—	—	1.1
2–3	13.9	98.0	1.5	—	0.5	—
3–4	20.3	97.5	1.5	0.5	—	0.5
4–5	26.0	96.4	1.2	2.4	—	—
5–6	25.8	96.8	1.6	1.6	—	—
6–7	28.4	95.9	4.1	—	—	—
7–8	28.2	97.3	2.7	—	—	—
8–9	32.7	93.9	6.1	—	—	—
9–10	26.6	100.0	—	—	—	—

Such a profile can be calculated exactly as for an "actual-age profile," providing we have the relevant prison and lockup data available, and in this section we briefly compare the two kinds of profiles for a subgroup of our data set. In our case, the required data are available only for adults (aged 18 years or more), so for the comparison of profiles we restrict attention to this subset of the overall data.

First, Tables V and VI show, for the whole data set, the proportion having some prison or lockup time, and the distribution of that time, separately for each arrest event. The tables show that, overall, there is relatively little time spent in prison or lockup, so we would expect there to be little difference between street-age profiles and actual-age profiles for this population. This is borne out by Fig. 12, which gives the profiles for male non-Aboriginal and male Aboriginal arrestees whose first arrest occurred at between 22.5 and 23.5 years. For Aborigines, the street-age profile is shifted slightly to the left (as would be expected) but otherwise closely parallels

Table VI. Distribution of Nonstreet Time for Female Aborigines

Between arrests	Percentage with some prison or lockup time	Total amount of prison or lockup time (months)				
		% <6	% 6–12	% 12–24	% 24–36	% 36+
1–2	0.2	95.8	1.8	1.8	—	0.6
2–3	2.4	86.6	7.5	2.6	1.9	1.4
3–4	5.0	87.5	6.6	3.5	2.1	0.3
4–5	8.0	88.5	5.9	4.4	0.6	0.6
5–6	11.0	88.5	7.4	3.4	0.5	0.2
6–7	10.6	85.2	6.6	6.6	1.2	0.4
7–8	16.5	87.8	9.3	2.9	—	—
8–9	15.8	87.7	6.8	5.5	—	—
9–10	15.5	84.3	10.8	3.9	1.0	—

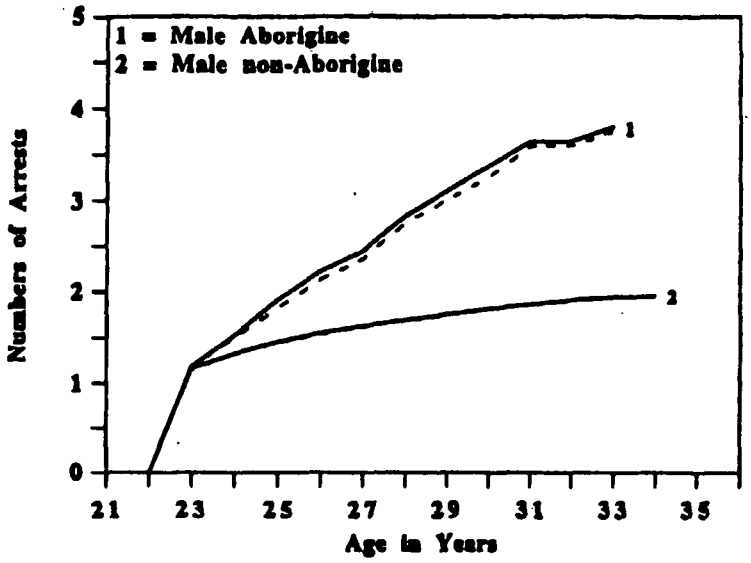

Fig. 12. Estimated arrest profiles by race for male, first arrest at 23 years. Solid line, street age; dashed line, actual age.

the actual-age profile. In fact the profiles are not significantly different by comparison with the standard errors of estimation associated with the profiles. For non-Aborigines, no difference is discernible between the profiles.

We made the above comparison of profiles for a large number of subgroups of the adult male component of the database and always found nonsignificant differences between the profiles—in fact, the subgroup plotted in Fig. 12 is the one for which the largest difference was observed.

7. DISCUSSION

The new methodology presented here enables a vivid presentation to be made of data relevant to addressing the issues raised in Section 1. In relation to the Western Australian arrest population, it can be seen that age-at-onset is indeed associated with both the frequency and the intensity of subsequent criminal careers, while the issue of seriousness and the related issue of sequence of onsets can in principle be explored further.

Above all, however, the analysis reveals the dominance of Aboriginality—particularly male Aboriginality—as a factor in addressing the main issues. Of course, such a finding was already well-known in the light of the recidivism research and cross-sectional data contained in the Crime Research Centre's own regular statistical reports (Ferrante *et al.*, 1993, and prior and subsequent reports 1990–1995) and, more recently, the saturation analysis of Aboriginal contacts with the criminal justice system (Harding *et al.*, 1995; Broadhurst, 1997). However, our new method facilitates an immediate grasp of the nature and magnitude of these differences. For example, it can readily

be seen that male Aborigines entering the arrest population on average commence their arrest careers at a younger age, accelerate them more rapidly, and accumulate them to a markedly greater extent than any of the other race/sex subdivisions.

This manner of analyzing and displaying data also provides a vivid backdrop to discussions of both labeling theory (usually explored in the literature ethnographically or qualitatively) and its practical counterpart, diversion. The expected arrest profiles of Aboriginal males by age at first arrest, as shown in Fig. 3, for example, unequivocally raise questions of police practice of the sort explored in earlier Australian literature (New South Wales Anti-Discrimination Board, 1982; Gale *et al.*, 1990; Duguid, 1992). By the same token, the remarkable patterns evident from Table III demonstrate that the later the age-at-onset, the fewer will be the expected number of arrests between that age and any subsequent age selected as a comparison point. For example, for Aboriginal males, post-16 to age 22 arrests are influenced by age-at-onset in the following ways: for those arrested at 12, an average of 9.1 (12.0 − 2.9) arrests was estimated to have occurred in that 6-year period; for those arrested at 14, an average of 7.5 (9.8 − 2.3) arrests was expected; and for those arrested at 16, 6.3 (8.0 − 1.7) arrests were expected, on average (see columns 5–7 in Table III). These data would suggest that Nagin and Farrington's (1992) finding in the Cambridge study—that the inverse relationship between the age-at-onset and the persistence of offending was attributable entirely to the existence of a previously existing criminal potential and that an early age-at-onset had no additional impact on persistence—is by no means a universal one, at any rate, for a Western Australian population of young male Aboriginal offenders. On the contrary, data like these lend presumptive support to the notion that early entry into the criminal justice system is in itself a factor which exacerbates persistence, and that the longer that formal entry into the criminal justice system can be deferred, the fewer will be the subsequent contacts. In other words, diversion, if it is feasible in the particular circumstances, may be highly desirable.

It should be emphasized that, although Aboriginality is properly singled out for focus in the Western Australian and indeed the Australian context, the methodology is equally applicable to any other categories that constitute comparable focal groups in any other jurisdiction.

The robustness of our method to the definition of an offender's "age"—whether adjusted for street time or not—is shown by the lack of differences observed between the two types of profiles in the analysis of Section 6. It could be argued that a larger difference would be found in subgroups of violent or other offenders who receive relatively long prison sentences—but even after controlling for various sentence types, we found that adjusting

for nonstreet time produced insignificant differences, because the numbers of such offenders are small, and the prison or lockup time forms a relatively small component of the offender's age—at least for our data set. Furthermore, in relation to juveniles, the much more parsimonious use of custodial sentences and the shorter periods of incarceration for them encourage us in the belief that the same conclusions are valid with respect to this group.

From this point one could readily move on to a cogent quantitative analysis of contemporary criminal justice policy issues, such as the efficacy of "three strikes" laws or the impact of boot camps and the like upon reoffending patterns and the utility of diversion from the formal justice system. This could be done by identifying within the relevant populations those who have been subjected to the particular intervention, then calculating their expected arrest profiles for comparison with those of the arrest population generally. Of course, these first analyses would, in criminological terms, be exploratory rather than definitive, requiring other variables to be controlled, and certain to benefit from being melded with qualitative research.

Finally, the current approach could permit more reliable projections to be made as to the crossover rates from juvenile to adult criminal career. Pursuing this prime criminological question, Wolfgang *et al.* (1972, pp. 125–129) used mathematical methods to explore this key question which are crude by today's standards. As Broadhurst and Loh (1995, p. 311) have stated, "The development of longitudinal criminal justice data bases and improved ways of handling statistical problems, such as censoring, render earlier prediction models obsolete." The new method of displaying and analyzing data described here would likewise enhance research in this area.

8. CONCLUSION

This paper has described new methodologies for displaying and analyzing arrest profiles and arrest career projections. Applied in relation to comprehensive retrospective databases, they permit fundamental criminological questions such as the impact of age-at-onset upon subsequent criminal careers to be revisited. Statistical models do not obviate the need for supporting ethnographic and qualitative material to be gathered and analyzed in addressing these questions, but they do ensure that the backdrop for policy discussion and theoretical developments may be grounded more firmly on comprehensive and reliable data.

APPENDIX: PRECISION OF THE ESTIMATOR

Let $\hat{E}_{KM}(t)$ denote the estimator of $E(N(t))$ defined in (2). We can calculate an upper bound for the variance of $\hat{E}_{KM}(t)$ by using the inequality

$$\mathrm{Var}(X+Y)=\mathrm{Var}(X)+\mathrm{Var}(Y)+2\,\mathrm{Cov}(X,Y)\le(\sqrt{\mathrm{Var}(X)}+\sqrt{\mathrm{Var}(Y)})^2$$

valid for any random variables X and Y. Thus we obtain for the standard error of $\hat{E}_{KM}(t)$ the upper bound

$$\sqrt{\text{Var}(\hat{E}_{KM}(t))} \leq \sum_{j \geq 1} \sqrt{\text{Var}(\hat{F}_{nj}(t))}$$

We can use standard formulae for the variance of the EDF and the KME (e.g., Kalbfleisch and Prentice, 1980, p. 14) to estimate the quantity on the right-hand side. The confidence intervals in the figures in this paper were found in this way.

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