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Recent Research (*N* = 9,305) Underscores the Importance of Using Age-Stratified Actuarial Tables in Sex Offender Risk Assessments

Richard Wollert[1,2], Elliot Cramer[3], Jacqueline Waggoner[4], Alex Skelton[5], and James Vess[6]

Abstract

A useful understanding of the relationship between age, actuarial scores, and sexual recidivism can be obtained by comparing the entries in equivalent cells from "age-stratified" actuarial tables. This article reports the compilation of the first multisample age-stratified table of sexual recidivism rates, referred to as the "multisample age-stratified table of sexual recidivism rates (MATS-1)," from recent research on Static-99 and another actuarial known as the Automated Sexual Recidivism Scale. The MATS-1 validates the "age invariance effect" that the risk of sexual recidivism declines with advancing age and shows that age-restricted tables underestimate risk for younger offenders and overestimate risk for older offenders. Based on data from more than 9,000 sex offenders, our conclusion is that evaluators should report recidivism estimates from age-stratified tables when they are assessing sexual recidivism risk, particularly when evaluating the aging sex offender.

Keywords

age invariance, ASRS, sexual recidivism, Static-99, MATS-1

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Recent meta-analyses of the offender recidivism literature have identified static factors such as an offender's developmental history and prior criminal convictions that are empirically related to recidivism (Hanson & Bussiere, 1998; Hanson & Morton-Bourgon, 2005). Following directly from this line of research, risk assessment instruments have been developed through an actuarial methodology that are demonstrably predictive of sexual or violent recidivism among adult male sexual offenders (Doren, 2002; Hanson, 2009; Quinsey, Harris, Rice, & Cormier, 1998). These actuarial instruments include the Violence Risk Appraisal Guide (Harris, Rice & Quinsey, 1993), the Sex Offender Risk Appraisal Guide (Harris et al., 2003; Quinsey et al., 1998), the Rapid Risk Assessment of Sexual Offense Recidivism (RRASOR; Hanson, 1997), the Static-99 (Hanson & Thornton, 2000), and the Minnesota Sex Offender Screening Tool–Revised (MnSOST-R; Epperson et al., 1998; Wollert, 2002, 2003). At present, actuarial assessment is regarded as a core assessment methodology and one of only two acceptable or best-practice approaches to the forensic assessment of the sex offender (Hanson, Morton, & Harris, 2003).

In a separate but parallel literature, the relationship between advancing age and sexual recidivism has been studied extensively over the last 10 years. Describing this work in a recently published article, Barbaree and his colleagues (Barbaree, Langton, Blanchard, & Cantor, 2009, pp. 443-444) reported that

> A large body of evidence has recently accumulated indicating that recidivism in sex offenders decreases with the age of the offender at the time of his release from custody (Barbaree, Blanchard, & Langton, 2003; Fazel, Sjőstedt, Längstrőm, & Grann, 2006; Hanson, 2002, 2006; Lussier & Healey, 2010[1]; Prentky & Lee, 2007; Skelton & Vess, 2008; Thornton, 2006). These reductions in recidivism are consistent across studies (Barbaree & Blanchard, 2008) and are similar to reductions in recidivism (both violent and nonviolent) in the aging criminal (Hirschi & Gottfredson, 1983; Moffitt, 1993; Sampson & Laub, 2003). According to Wollert (2006), the aging effect has been recognized as one of the most robust findings in the field of criminology. In a seminal and influential article, Hirschi and Gottfredson (1983) pointed to the "invariance" of this relationship in that crime rates decreased with age for offender groups who (a) lived in different centuries, (b) came from different countries, (c) differed with respect to age and gender, (d) were at large in the community or incarcerated, and (e) committed different types of crimes (Wollert, 2006).

The first generation of actuarial instruments for sex offender risk assessment incorporated the age of offenders into the evaluation of risk through the inclusion of a single item. For example, the RRASOR, the Static-99 and the MnSOST-R included an item that added a point to the score of offenders who were released from custody prior to a critical age cut off (25 years of age for the RRASOR and Static-99; 30 years of age for the MnSOST-R).

This method of accounting for the age effect obviously does not make allowances for reductions in recidivism risk that occur after the critical cutoff age specified in the item. For the RRASOR and Static-99, this means that age-related changes in recidivism occurring after the age of 25 will not be captured in the evaluation. In recognition of this fact, Helmus, Thornton, & Hanson (2009, October) have created a revised version of the Static-99 (Static-99R), incorporating a revised age item that adjusts for the age of the offender past age 60. According to their new age item, the item makes no adjustment for age for offenders aged 35 to 39.9 at the time of their release from custody. For offenders 18 to 34.9, a single point is added to their Static-99 score. For the aging offender (ages 40-59.9 and ages 60 and older), one or three points are subtracted from the Static-99 score. Once an evaluator obtains a final actuarial score, no further consideration of the age issue is made.

The present article proposes an alternative method of incorporating age into risk assessment procedures. Actuarial instruments always provide some type of "experience table" or formula from which empirically based recidivism percentages may be derived for specified follow-up periods for each actuarial score value. Once an evaluator has obtained an actuarial score for an offender, she can usually look up the tabled values for that particular actuarial score to obtain an estimate of recidivism risk.

We believe that "age-stratified" experience tables, as proposed by Wollert (2006, p. 73), provide a particularly valuable resource that takes the effects of age on sexual recidivism into account. Two such tables have already been disseminated in peer-reviewed articles. The first was compiled for the Static-99[2] (Hanson, 2006). This table is based on three times the number of offenders as the original Static-99's experience table (*N* = 3,425 in Hanson [2006] vs. 1,086 in Hanson & Thornton [2000]) and reports 5-year recidivism rates (see Hanson, 2006, Table 3) for four score levels (low [L] = 0-1 point, moderately low [ML] = 2-3 points, moderately high [MH] = 4-5 points, high [H] = 6 or more points) stratified by five age groups (18-24.9, 25-39.9, 40-49.9, 50-59.9, 60 years old and over). Consequently, the table includes 20 different cells (i.e., four score levels by five age groups equals 20 recidivism estimates). The base rate of sexual recidivism for all offenders in Hanson's age-stratified table was 12%.

The second age-stratified table was compiled by Skelton and Vess (2008) using the Automated Sexual Recidivism Scale (ASRS). The ASRS contains 7 of the 10 original Static-99 items (the three missing items code whether the examinee ever lived with a lover for at least 2 years, had any unrelated victims, or had any stranger victims). Tapping into an electronic database of all 5,880 New Zealand sex offenders released from prison over a 15-year period, the ASRS assigns offenders to one of six discrete score groups (0, 1, 2, 3, 4, and 5 and above). This risk scoring system enables the combination of these groups into more inclusive subsets. For example, Table 3 in Skelton and Vess (2008) reported 18 sexual recidivism rates for three risk categories (low [L] = 0 points, medium [M] = 1-3 points, high [H] = more than 3 points), each with six age groups (less than 20, 20-30, 31-40, 41-50, 51-60, more than 60 years old). The base rate of sexual recidivism for all offenders in Skelton and Vess' age-stratified table was 9%.

Both of these empirically derived age-stratified experience tables confirm that recidivism declines with advancing age. A useful understanding of the relationship between age, actuarial scores, and sexual recidivism may therefore be obtained by comparing the entries in these two tables and contrasting them with the entries from an experience table that has not been age stratified. Five preparatory steps should be taken to facilitate the comparisons and contrasts required by this type of study. The first would remove the age item from the scores entered in both tables so that age is not entered into the analysis twice. The second would subdivide offenders into comparable risk levels in both tables. The third would, to the extent possible, subdivide offenders into comparable age groups in both tables. The fourth would calculate the "likelihood ratio" (Mossman, 2006; Wollert, 2007; Wollert & Waggoner, 2009) for each test score in each age group for each table. Finally, the fifth would control for any differences in likelihood ratios and base rates.

The next five sections of this article describe the preparatory procedures we implemented to undertake the foregoing comparisons. The sixth summarizes our data analyses and results. In the concluding section, we discuss the statistical advantages of age-stratification for estimating recidivism risk and consider the implications of our findings and some of our analytical methods for risk assessment procedures, the development of actuarial tests, and forensic testimony about actuarial data.

Step 1: Removing the Age Item From Actuarial Scores

As noted earlier, the original Static-99 contained an age item that assigned an extra point to those who were younger than 25 years old at their release from custody. The ASRS contains this same age item. Inclusion of an age item was an attempt by the test developers to insure that the effects of aging on recidivism were incorporated in the actuarial instrument. The development of age-stratified experience tables for these instruments is as an alternative way of incorporating aging into the assessment process.

It is important to remove the age item from an actuarial instrument when this approach is used, otherwise, the age factor will be counted twice in the analysis. Retaining the age item in the test would then have the effect of assigning those who are under 25 years old to higher risk groups than appropriate, generating risk estimates that are too low for them. The top panel of Table 1 shows the original Static-99 age-stratified experience table (Hanson, 2006) in which one extra point is assigned to each offender under 25.

The first three members of our team used a version of the formula for calculating conditional probability, described in Waggoner, Wollert, and Cramer (2008), to respecify table entries in the age-stratified experience table reported by Hanson (2006). The bottom panel of Table 1 shows the effect of removing the extra point for being under 25 and the increases in the cell-wise recidivism rates that were subsequently obtained. This table shall hereafter be referred to as "Respecified Static-99" or, more concisely, as "RS-99."

Waggoner et al. (2008) used this probabilistic reasoning to respecify Static-99 scores (removing the age item) because frequency data were unavailable. Frequency data were available for the ASRS and our current team respecified the recidivism rates

Table 1. Five-Year Sexual Recidivism (*R*), Subdivided by Age and Risk Levels (L = Low, ML = Moderately Low, MH = Moderately High, H = High), for Static-99

	Age at release											
	18-24.9		25-39.9		40-49.9		50-59.9		60 and older		All ages	
Static-99 levels	*n*	*R*	*n*	*R*	*n*	*R*	*n*	*R*	*n*	*R*	*n*	*R*
Original results												
L	17	5.8[a]	486	6.7	321	5.5	159	2.5	112	0.0	1,095	5.3[a]
ML	275	7.6[a]	590	11.7	260	6.7	126	4.3	56	3.0	1,307	8.7[a]
MH	199	24.6[a]	321	24.3	124	13.8	63	19.4	25	4.8	732	21.4[a]
H	61	35.5[a]	116	37.5	71	25.7	32	24.3	11	9.1	291	31.6[a]
All levels	552	16.2	1,513	14.4	776	8.8	380	7.5	204	2.0	3,425	12.0
Respecified Static-99 results												
L	177	7.5[a]	486	6.7	321	5.5	159	2.5	112	0.0	1,255	5.6[a]
ML	216	12.8[a]	590	11.7	260	6.7	126	4.3	56	3.0	1,248	9.7[a]
MH	117	26.2[a]	321	24.3	124	13.8	63	19.4	25	4.8	650	21.4[a]
H	42	40.3[a]	116	37.5	71	25.7	32	24.3	11	9.1	272	32.4[a]
All levels	552	16.2	1,513	14.4	776	8.8	380	7.5	204	2.0	3,425	12.0

Note: The top panel shows the original results that were obtained when an extra point was given to each offender less than 25 years old. The bottom panel shows the results when the affected cells were respecified by not double-counting this point (RS-99). RS-99 = Respecified Static-99.
Source: Hanson (2006).
a. Denotes the affected cells.

for the two youngest offender groups by simply eliminating the dichotomous age item from the risk factor battery and recalculating the observed proportion of recidivists among the youngest offenders with low, medium, and high scores on the ASRS. The top panel of Table 2 shows the recidivism percentages originally reported by the last two members of our team (Skelton & Vess, 2008). The bottom panel shows the effect of removing this point and the increases in the cell-wise recidivism rates that were obtained.

Step 2: Standardizing the Risk Levels in Each Table

The age-stratified experience table described by Hanson (2006) for the Static-99 subdivided offenders into four risk level groups, whereas the table reported for the ASRS by Skelton and Vess (2008) subdivided offenders into three risk level groups. To standardize the number of risk levels between these two tables, we combined the RS-99 data for those offenders who had ML and MH scores, so that both tables had three levels of risk. By doing so, we created two tables with roughly equivalent proportions of offenders in each risk level for the RS-99 table and the ASRS table (low risk

Table 2. Sexual Reoffending by ASRS Risk Levels (L = Low, M = Medium, H = High) and Different Age Groups Showing the Number of Offenders (*n*) Released From New Zealand Prisons From 1990 to 2004 and the Percentage Who Recidivated (*R*)

	Age at release													
	<20		20-30		31-40		41-50		51-60		>60		All ages	
ASRS levels	*n*	*R*	*n*	*R*	*n*	*R*	*n*	*R*	*n*	*R*	*n*	*R*	*n*	*R*
L	0	0[a]	341	5.9[a]	668	4.9	561	3.0	402	2.0	363	3.0	2,335	4.0[a]
M	213	13.1[a]	1,051	13.0[a]	891	14.0	568	7.0	315	4.1	181	3.9	3,219	11.0[a]
H	4	25.0[a]	99	26.3[a]	88	30.7	80	25.0	37	18.9	18	5.6	326	25.1[a]
All	217	13.4	1,491	12.3	1,647	11.2	1,209	6.4	754	3.7	562	3.4	5,880	9.0
Respecified results														
L	116	9.5[a]	581	7.1[a]	668	4.9	561	3.0	402	2.0	363	3.0	2,691	4.5[a]
M	101	16.8[a]	861	14.6[a]	891	14.0	568	7.0	315	4.1	181	3.9	2,917	11.3[a]
H	0	—[a]	49	26.5[a]	88	30.7	80	25.0	37	18.9	18	5.6	272	25.0[a]
All	217	13.4	1,491	12.3	1,647	11.2	1,209	6.4	754	3.7	562	3.4	5,880	9.0

Note: The top panel shows the original results that were obtained when an extra point was given to each offender less than 25 years old. The bottom panel shows the results when the affected cells were respecified by not double-counting this point. ASRS = Automated Sexual Recidivism Scale.
Source: Skelton and Vess (2008).
a. Denotes the affected cells.

Table 3. Age-Wise sexual Recidivism Rates for Sex Offenders With Low (L), Medium (M), and High (H) Scores on the RS-99 Versus the ASRS (Based on the Bottom Panels of Tables 1 and 2)

RS-99 (L = 0 and 1, M = 2 through 5, and H = 6 and above)					
	18-39.9	40-49.9	50-59.9	60 and older	All ages
L	6.8	5.5	2.5	0.0	5.6
M	16.6	8.9	9.0	4.0	13.7
H	38.6	25.7	24.3	9.1	32.4
All levels	14.9	8.8	7.5	2.0	12.0
ASRS (L = 0, M = 1 through 3, H = 4 and above)					
	18-40	41-50	51-60	More than 60	All ages
L	6.2	3.0	2.0	3.0	4.5
M	14.5	7.0	4.1	3.9	11.3
H	29.2	25.0	18.9	5.6	25.0
All levels	11.7	6.4	3.7	3.4	9.0

ASRS = Automated Sexual Recidivism Scale; RS-99 = Respecified Static-99.

included 32% and 40% of the number of offenders in each table respectively; moderate risk included 60% and 55%; high risk included 8.5% and 5.5%). The results of this step are presented in Table 3.

Step 3: Standardizing the Age Categories in Each Table

The age-stratified experience table presented by Hanson (2006) and Waggoner et al. (2008) subdivided offenders into five age groups whereas the ASRS subdivided them into six age groups. To standardize the number of age groups to the greatest extent possible we combined the RS-99 data in Table 1 for those in the 18 to 24.9 age group with the data for the 25 to 39.9 group. This operation generated the first column in the top panel of Table 3. Then we combined the ASRS data in Table 2 for 18- and 19-year olds with the data for 20- to 30-year olds and 30- to 40-year olds, yielding the first column in the bottom panel of Table 3.

Step 4: Calculating the Likelihood Ratios for the Cells in Each Table

Doren (2004) compared the 5-year score-wise recidivism rates for the developmental cohorts of Static-99 (Hanson & Thornton, 2000) with other data sets he assembled so that they had base rates ranging from a low of 6% to a high of 40%. He claimed his analysis showed that "each 5-year recidivism percentage associated with a . . . Static-99 score was replicated" and that Static-99 "demonstrated a high degree of stability in those percentages even as the underlying recidivism base rates were varied from quite low to quite high" (p. 33). He also interpreted this finding to mean that sex offender evaluators "need not concern themselves about the underlying population base rate when high risk is shown" (p. 33).

Mossman (2006) disputed Doren's (2004) results. Drawing on Bayes's Theorem (Bayes, 1764), he pointed out that differences in score-wise risk percentages from one sample to another are due to the combined effects of (a) differences between the samples in their base rates and (b) differences between samples in the likelihood ratios for comparable scores. He also showed that the values of the likelihood ratios for Doren's high base rate cohorts were small and that his low rate cohorts had large likelihood ratios. The risk percentages for Doren's cohorts were therefore similar to one another and similar to the Static-99 developmental sample only because the potential of high rates for elevating risk estimates was neutralized by low likelihood ratios while the potential of low rates for reducing risk estimates was neutralized by high likelihood ratios.

Mossman (2006) also corrected Doren's (2004) exhortation to evaluators to assume that "base rates don't matter" when it comes to the interpretation of actuarial test scores. Specifically, he observed that "directly comparing percentages of offenders falling in each risk category of different samples is likely to be misleading if their respective likelihood ratios are not compared" (p. 43). Furthermore, since the power of a test score for differentiating sexual recidivists from nonrecidivists is reflected in likelihood ratios rather than risk percentages, Mossman recommended that "to appropriately evaluate the 'stability' of an assessment instrument's performance across populations and settings . . . investigators should . . . isolate and examine the 'discriminative properties' (i.e., likelihood ratios) of the instrument alone, independent of the population or setting-specific 'base rate'" (p. 43).

Table 4. RS-99 and ASRS Likelihood Ratios for Each Risk and Age Group

		Age groups			
		18-39.9	40-49.9	50-59.9	60 & older
Risk groups		18-40	41-50	51-60	More than 60
Low	RS-99	0.42	0.59	0.31	0.68
Low	ASRS	0.50	0.46	0.51	0.89
Medium	RS-99	1.11	0.98	1.20	0.82
Medium	ASRS	1.27	1.11	1.12	1.15
High	RS-99	3.55	3.43	4.06	3.00
High	ASRS	3.10	4.91	6.10	1.70

Note: The first row of age groups are for RS-99. None of the values of equivalent pairs differed at the .05 level. ASRS = Automated Sexual Recidivism Scale; RS-99 = Respecified Static-99.

Following Mossman's (2006) logic, we calculated the likelihood ratios for each Static-99 score in each RS-99 age group and for each ASRS test score in each ASRS age group. Each of these calculations involved three steps. First, the "likelihood for recidivism" was obtained by dividing the number of recidivists in a given cell by the number of recidivists in the age group that included the cell. Second, the "likelihood for nonrecidivism" was obtained by dividing the number of nonrecidivists in the cell by the number of nonrecidivists in the age group. Third, the "age-wise likelihood ratio" was obtained by dividing the likelihood for recidivism by the likelihood for nonrecidivism.

During this analysis we noticed that the "60 and over" group reported by Hanson (2006) and Waggoner et al. (2008) included only 204 offenders. Furthermore, only 11 of these offenders had high scores and none recidivated who had low scores. These results concerned us because we were unable to calculate a likelihood ratio for older offenders with low Static-99 scores and also because we felt the likelihood ratios for older offenders might be unstable because of their small numbers.

We therefore contacted the members of the Static-99 research team, who provided us with 5-year follow-up data on 394 sex offenders in the 60 and over group (L. Helmus, personal communication, December 17, 2009). Twelve offenders in this group recidivated—four with high scores, four with medium scores, and four with low scores. There were also 382 nonrecidivists in this group—43 with high scores, 152 with medium scores and 187 with low scores. The recidivism rate was therefore 9% for older offenders with high scores (4/43 = 9%), 3% for older offenders with medium scores (4/152 = 3%), and 2% for older offenders with low scores (4/187 = 2%).

The foregoing contribution enabled us to complete our analysis of the likelihood ratios for the ASRS and RS-99. Table 4 presents the comparable likelihood ratios for RS-99 and the ASRS. When we conducted tests for determining whether any pair of ratios differed from one another (Mossman, 2006),[3] we found no differences.

Step 5: Comparing Actuarial Tables While Controlling for Differences in Likelihood Ratios and Sexual Recidivism Rates

Although each cell entry in an actuarial table is typically calculated by simply dividing the number of recidivists by the number of offenders in the cell, each entry is also a conditional probability estimate (Donaldson & Wollert, 2008; Wollert, 2010 March). Generally, a conditional probability is written as $P(R^+ \mid S)$ and read as the "observed probability of recidivism (R^+) among those sex offenders who share a set of conditions (S) such that they are all a particular age and have been assigned a particular test score" (the vertical bar in the conditional probability term means "given that").

The similarity between two age-stratified tables may be assessed if sufficient probability data are available to support the compilation of two other tables of conditional probabilities. This is done by combining the base rate data from the first table with the likelihood ratios from the second and then combining the base rate data from the second table with the likelihood ratios from the first. The entries in these tables, which are independent of one another, may then be averaged to generate a "multisample age-stratified table" and the averages in this table may then be contrasted with an age-restricted table that has been compiled to reflect only score-wise recidivism rates. We used the following procedures to compile both tables in the present study.

1. We relied on RS-99 (the "all levels" row of the top panel of Table 3) to estimate the base rate of recidivism for each age group and on the respecified ASRS (the bottom panel of Table 3) to derive the age-wise LRs and thus estimate the extent to which the scale discriminates between recidivists and nonrecidivists for each age and risk group.
2. Using Bayes's Theorem, we combined the age-wise recidivism rates from RS-99 with the likelihood ratios for the ASRS (see Table 4) to compile a table of conditional probabilities/risk percentages that controlled for age-wise recidivism rates.[4] This age-stratified table is presented as the top panel of Table 5.
3. We repeated the foregoing steps, relying on the respecified ASRS (see the "all levels" row of the bottom panel of Table 3) to estimate the base rate of recidivism for each age group and, on RS-99 (the top panel of Table 3), to derive the age-wise LRs (presented in Table 4). The age-stratified table generated by these operations is presented as the bottom panel of Table 5.
4. We averaged the cells in Table 5 that corresponded to one another, generating the multisample age-stratified table of sexual recidivism rates presented in Table 6. We refer to this table as the multisample age-stratified table of sexual recidivism rates (MATS-1) because it is the first multisample age-stratified table of sexual recidivism rates that we are aware of that has been compiled using our procedures.

Table 5. Estimated Recidivism Rates Based on Age-Wise Recidivism Rates and Likelihood Ratios From the RS-99 and ASRS

	From RS-99 age rates and ASRS likelihood ratios			
	18-39.9	40-49.9	50-59.9	60 & over
L	9.8	4.2	3.9	1.8
M	21.7	9.7	8.3	2.2
H	40.3	32.0	33.1	3.3
All levels	14.9	8.8	7.5	2.0
	From ASRS age rates and RS-99 likelihood ratios			
	18-40	41-50	51-60	More than 60
L	5.3	3.8	1.2	2.3
M	12.9	6.3	4.4	2.8
H	32.2	18.9	13.3	9.5
All levels	11.6	6.4	3.7	3.4

ASRS = Automated Sexual Recidivism Scale; RS-99 = Respecified Static-99.

Table 6. First Version of the Multisample Age-Stratified Table of Sexual Recidivism Rates, Obtained by Averaging the Estimated Recidivism Rates in Table 5

	Age groups			
Scores	18-39.9	40-49.9	50-59.9	60 & over
Low	7.6	4.0	2.6	2.0
Medium	17.3	8.0	6.4	2.5
High	36.2	25.5	23.2	6.4
All levels	13.2	7.6	5.6	2.7

5. We averaged the corresponding score-wise recidivism rates in the “all ages” columns of the top and bottom panels of Table 3 to derive a set of age-restricted recidivism estimates. The age-restricted recidivism estimate was 5% for offenders with low scores, 12% for those with medium scores, and 29% for those with high scores.

Data Analysis

To justify averaging the cells in Table 5, we calculated the likelihood ratios for the RS-99R and ASRS for each test score when age groups were collapsed into those

Table 7. Likelihood Ratios for Younger Versus Older Sex Offenders for Each RS-99 and ASRS Score

	RS-99		ASRS	
Risk levels	Up to 40	More than 40	Up to 40	More than 40
Low	1.24	.74	1.41	.59
Medium	1.26	.56	1.33	.47
High	1.37	.63	1.24	.79

Note: All likelihood ratio tests reached the .05 level of significance. ASRS = Automated Sexual Recidivism Scale; RS-99 = Respecified Static-99.

who were younger than 40 versus those who were more than 40. Recidivism data for each instrument was therefore aggregated into six cells that reflected three score groups (high, medium, and low) and two age groups (younger and older). We adopted 40 as a break point because this was about the average age of sex offenders in RS-99 and the ASRS.

Then we calculated the "score-wise likelihood ratio" for each aggregated cell in three steps. The likelihood for recidivism was obtained first by dividing the number of recidivists in a given cell by the number of recidivists in the score group that included the cell. The likelihood for nonrecidivism was obtained next by dividing the number of nonrecidivists in the cell by the number of nonrecidivists in the score group. Finally, the score-wise likelihood ratio was obtained by dividing the likelihood for recidivism by the likelihood for nonrecidivism.

All other things being equal, those who have above average scores on an "external" (Hanson, 2006), "maturational" (Barbaree et al., 2009), "dynamic" (Olver, Wong, Nicholaichuk, & Gordon, 2007), or "cohort" (Abbott, 2009; Thornton & Helmus, 2009) risk factor that will truly enhance test performance will be more likely to recidivate than those whose scores are below average. This predictive power, in turn, will be reflected in likelihood ratios that are greater than 1 for those with above average scores and likelihood ratios that are smaller than 1 for those with below average scores (Wollert, 2007). On the assumption that information about age enhances risk prediction for all test scores, we tested whether the likelihood ratios for the younger offenders were larger than the likelihood ratios for older offenders. All six of the tests in this analysis reached the .05 level of significance. The specific values of the various pairs of likelihood ratios that were compared are presented in Table 7.

After this we analyzed the extent to which recidivism estimates based on age and actuarial scores were more accurate than recidivism estimates based only on scores by compiling a series of line graphs that plotted the average estimated conditional probabilities presented in Table 5, broken down by age and score level, with the average score-wise recidivism rates of 5%, 12%, and 29%. These graphs are presented in Figure 1.

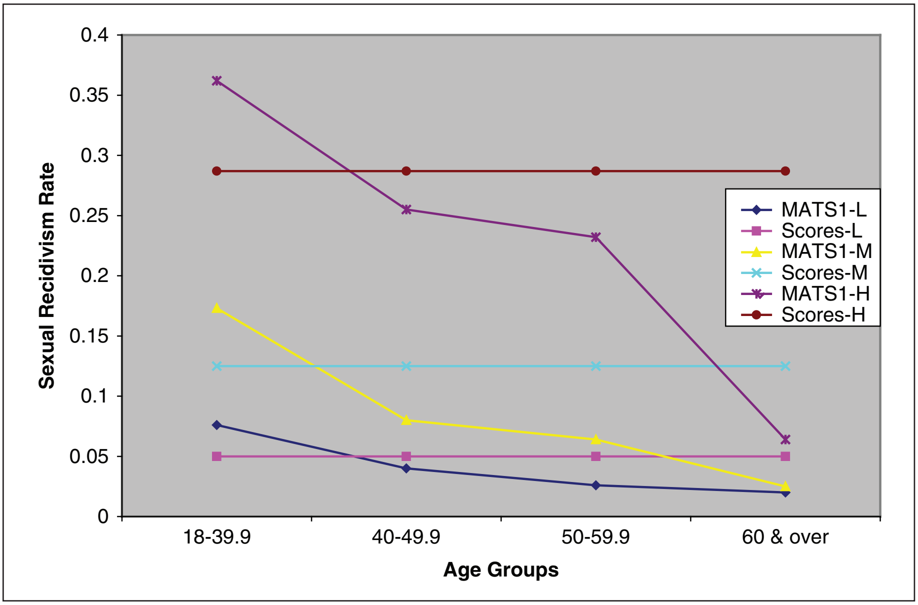

Figure 1. Multisample age-stratified table of sexual recidivism rates (MATS-1) recidivism estimates based on age and actuarial scores (L = low, M = medium, H = high) are clearly more accurate than estimates based only on scores

It is clear from Figure 1 that the age invariance effect is a highly reliable phenomenon. It is also obviously the case that our age-stratified actuarial estimates recidivism more accurately than an age-restricted alternative, and that this effect is most evident for offenders in the high risk group.

Discussion

The foregoing research contributes in a number of ways to sex offender risk assessment and management. Consistent with the findings of Waggoner and her colleagues (Waggoner et al., 2008), the results presented in Tables 1 and 2 emphasize the importance of eliminating the age item when age-stratified actuarial tables are compiled. Tables 3, 5, and 6 reconfirm the age invariance theory and suggest, consistent with Wollert's (2006) recommendations, that treatment and supervision resources should be concentrated on the youngest offender groups. Figure 1 shows that age-stratified actuarials such as the MATS-1 provide more accurate estimates of recidivism risk than age-restricted instruments, which overestimate the risk of recidivism for older offenders because they ignore the impact of desistance processes that occur throughout the life span (Lussier, Tzoumakis, Cale, & Amirault, 2010; Sampson & Laub, 2003, 2005) on criminal activity. Other advantages of the MATS-1 are that it covers an 8-year risk period rather than a 5-year period and was derived from one data set for a convenience sample that includes cohorts from many different countries (the RS-99) and a second data set for a true exhaustive sample (the ASRS). The averaged 10-year sexual recidivism rate for the latter sample was 9%, which is consistent with the 5-year recidivism rate of 7% that Wollert and Waggoner (2009) reported for a representative sample of 17,697 U.S. sex offenders who were released from incarceration.

Our analytical methodology also provides forensic experts with an algorithm for making a quantitative evaluation of the precise extent to which "a factor external to an evaluation scheme contributes information to risk assessment" (Hanson, 2006, p. 353). If the algorithm shows the likelihood ratio for a factor, "conditioned on all other known facts with regard to recidivism over some defined time interval" (Vrieze & Grove, 2010, p. 388), differs from 1.0, an evaluator may justifiably generate a recidivism estimate by combining the likelihood ratio with whatever base recidivism rate is most appropriate. She may also testify in court that it aids in the identification of sexual recidivists because it satisfies the "principle of all relevant evidence," which is fundamental to the use of inductive logic for reaching recidivism decisions.[5]

Helmus, Thornton, and Hanson (2009, October) have suggested that one may include age in logistic regression equations as an alternative to age-stratified tables for predicting the probability of recidivism. This would be an excellent solution if there were good reason to believe that the data followed a logistic curve which ranges from a probability of 0 to a probability of 1 and is symmetric about a probability of .5 (Pampel, 2000).

It is unjustified, however, to use the logistic curve or any other smooth function to predict the probability of recidivism unless the values that are used to do so reasonably correspond with the definition of a scale. Whether one refers to them as "scale values," "total points," or "scores," the Static-99 "risk categories" do not meet this criterion. Younger offenders, for example, are likely to be assigned a certain score based on items that reflect antisocial behavior whereas older offenders may get the same score because of items that reflect sexually deviant behavior (Barbaree et al., 2009). In addition, it is unreasonable to assume that the increase in risk that accompanies a one point increase for the large number of offenders with low scores (see Table 1) is the same for the small number of offenders with high scores.

Fitting a single logistic curve for different age groups is therefore inappropriate because the interaction between age, item content, and Static scores found by Barbaree and his colleagues suggests that substantially different curves need to be fit to different age groups. Furthermore, since most offenders have low scores, a logistic curve is likely to fit well at the low end of Static-99 but not at the high end that is typically more relevant for making decisions about release to parole or civil commitment.

In light of these and other limitations, a simpler and more accurate estimation method is to use the observed proportion of recidivists as estimates of the probability of recidivism. These are unbiased estimates of probabilities in a hypothetical underlying population and do not require investigators to adopt unjustified assumptions about some functional relationship with age. One can instead stratify Static-99 and ASRS scores by age, compiling recidivism data in actuarial tables that report the percentage of released sex offenders who sexually recidivate for each age group. This method is easy for evaluators to understand, use, and explain to the court. Hanson and the members of our research team have previously estimated the probability of recidivism by determining the observed proportion of recidivists in each cell of experience tables reported in several articles (Hanson, 2006; Hanson & Thornton, 2000; Skelton & Vess, 2008; Waggoner et al., 2008), and we recommend that this method be used today as well.

Our results might be questioned because of misconceptions about Bayes's Theorem. To estimate the conditional probabilities in our base-rate adjusted table we used equation (3), which is an explicit formulation of Mossman's (2006) suggestions for this type of analysis. Our fourth footnote sets forth a proof that equation (3) is a mathematical identity that follows directly from the definition of conditional probability. Nonetheless, a few sexual recidivism researchers have argued that "Mossman's (2006) corrections for variations in base rate are actually valid only when factors influencing the base rate are not associated with the actuarial items—an unlikely event" (Harris & Rice, 2007, p. 1648; also see Doren, 2006). These critics have yet to provide any mathematical justification for their position; and the fact that validity is a relative construct makes it meaningless without a very careful explication. Furthermore, many applications of Bayes's Theorem do not need to satisfy any of the assumptions that are typically discussed in relation to significance testing. In the case of our research, for example, it was possible to implement Mossman's procedures per equation (3) with minimal assumptions, because Hanson's 2006 research provided a complete set of data on base rates while Skelton and Vess' 2008 research provided a complete set of data on likelihood ratios. This and other advantages (Wollert, 2007) make Bayes's Theorem a simple and powerful method of analysis that can be very useful to clinicians and the courts for interpreting the meaning of actuarial data and for evaluating the adequacy of the procedures used to conduct sex offender risk assessments.

Overall, our research on one cohort of 3,425 sex offenders scored on RS-99 and another cohort of 5,880 sex offenders scored on the ASRS illustrates the stability of age-stratified actuarial tables for assessing sex offender recidivism risk and leads to the conclusion that age-restricted tables do not match the accuracy of age-stratified tables for predicting recidivism. Although further research will be necessary to isolate and verify which factors are the most efficient predictors of recidivism for different age groups, evaluators should report recidivism estimates from age-stratified or equivalent tables when they are assessing sexual recidivism risk, particularly when evaluating the aging sex offender (Barbaree, March 2010).

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Notes

1. Lussier and Healey's article was published in 2010. The correct current citation is included among our references.
2. The Static-99 includes items that take into account an offender's prior sex offenses and his sentencing history, violent nonsexual convictions, noncontact sex offense convictions, relationship to his victims, sex of his victims, marital status, and age.
3. We used the following formula described by Simel, Samsa, and Matchar (1991) and later used by Mossman (2006) to determine whether any pair of Static-99 and Automated Sexual Recidivism Scale (ASRS) discrimination or "likelihood ratios" differed from one another at the 95% confidence level:

$$LR_{L,U} = \text{Exp}\left\{\text{Ln } LR_i^+ \pm 1.96\sqrt{\left[\frac{1}{R_i^+} - \frac{1}{NR^+} + \frac{1}{R_i^-} - \frac{1}{NR^-}\right]}\right\} \quad (1)$$

where $LR_{L,U}$ represents the upper and lower limits of the confidence interval for the ASRS ratio; Exp is a power of *e,* the base of the natural logarithm; Ln is the natural (Naperian) logarithm; R_i^+ is the number of recidivists in a cell defined by a particular age group and test score; R_i^- is the number of nonrecidivists in the cell of interest; NR^+ is the total number of recidivists in the age group that includes the cell; and NR^- is the total number of nonrecidivists in the age group that includes the cell. An example would best explain how equation (1) was applied to one of the tests we conducted in evaluating the likelihood ratios in Table 4. A total of 967 offenders from the ASRS database had medium scores and were 18 to 30 years of age at the time of their release. R_i^+ was 144 because 144 offenders in this cell recidivated, and R_i^- was 823 because 823 did not. NR^+ was 209 because 209 of all the offenders in the 18 to 30 group recidivated and NR^- was 1,504 because 1,504 did not. The likelihood of recidivism for the cell of interest was therefore 144/209 = 0.689 and the likelihood of nonrecidivism was 823/1,504 = 0.547. The age-wise likelihood ratio for this ASRS cell was therefore .689/.547 = 1.26. The likelihood ratio for the comparable cell in respecified Static-99 (RS-99) was 1.12. Applying formula (1), the upper limit of the 95% confidence interval for the ASRS ratio was determined to be 1.584 and the lower limit was 1.002. The RS-99 ratio therefore did not differ from the ASRS ratio.

4. Two steps are involved in making this type of computation (Waggoner et al., 2008; Wollert, 2006; Wollert & Waggoner, 2009). The first is to calculate the "discrimination" or "likelihood ratio" for each of the particular risk categories (e.g., L, M, and H in the bottom panel of Table 2) under each particular age group in one actuarial table by using the following equation:

$$LR^{+} = \frac{P\left(S \mid R^{+}\right)}{P\left(S \mid R^{-}\right)}, \tag{2}$$

where LR^+ equals the accuracy, or "positive likelihood ratio," with which a particular risk category differentiates recidivists from nonrecidivists among all offenders who fall in a particular age group; $P(S \mid R^+)$ equals the percentage of all recidivists in the distribution of recidivists for a particular age group who are assigned to a particular risk category; and $P(S \mid R^-)$ equals the percentage of all nonrecidivists in the distribution of nonrecidivists for a particular age group who are assigned to a particular risk category. The second step consists of using an "odds ratio" version of the formula for the calculation of conditional probabilities, also known as Bayes's Theorem (Bayes, 1764), that combines the age-wise base rates from another actuarial table with the likelihood ratios from the first table. This formula is written as,

$$P\left(R^{+} \mid S\right) = \frac{\dfrac{P\left(R^{+}\right)}{1-P\left(R^{+}\right)} \times LR^{+}}{1 + \left(\dfrac{P\left(R^{+}\right)}{1-P\left(R^{+}\right)} \times LR^{+}\right)}, \tag{3}$$

where, per the last sentence of the second paragraph, $P(R^+)$ stands for the recidivism rate for a particular age group in the top panel of Table 3; and $P(R^+ \mid S)$ stands for the expected rate of recidivism on the condition that offenders of a particular age have been assigned to a particular risk category.

The following train of logic provides a mathematical justification for Equation (2):
If $O(R^+)$ stand for the odds of recidivism, then

$$O\left(R^{+}\right) = \frac{P\left(R^{+}\right)}{1 - P\left(R^{+}\right)} \tag{a}$$

$$O\left(R^{+} \middle| S\right) = \frac{P\left(R^{+} \middle| S\right)}{1 - P\left(R^{+} \middle| S\right)} \tag{b}$$

Solving (a) and (b) for $P(R^+)$ and $P(R^+ \mid S)$ and simplifying gives

$$P\left(R^{+}\right) = \frac{O\left(R^{+}\right)}{1 + O\left(R^{+}\right)} \quad \text{and} \quad P\left(R^{+} \middle| S\right) = \frac{O\left(R^{+} \middle| S\right)}{1 + O\left(R^{+} \middle| S\right)} \tag{c}$$

A form of Bayes's Theorem, frequently used in medical applications, (see, for example, Mossman, 2006, p. 49) is written in terms of odds as,

$$O(R^+ \mid S) = O(R^+) \times LR^+ \qquad \text{(d)}$$

$$= \frac{P\left(R^+\right)}{1 - P\left(R^+\right)} \times LR^+ \text{ using (a).}$$

$$P\left(R^+ \middle| S\right) = \frac{O\left(R^+ \middle| S\right)}{1 + O\left(R^+ \middle| S\right)} \text{ from (c).}$$

$$= \frac{\dfrac{P\left(R^+\right)}{1 - P\left(R^+\right)} \times LR^+}{1 + \left(\dfrac{P\left(R^+\right)}{1 - P\left(R^+\right)} \times LR^+\right)}, \text{ using (d).}$$

As an example of applying equation (3) in the study at hand, suppose that a total of 77 offenders from the ASRS database recidivated who were 41 to 50 years old at the time of their release and 20 offenders in this recidivistic cohort had high actuarial scores. Also, further suppose that a total of 1,132 offenders from the ASRS database who were 41 to 50 years old did not recidivate and that 60 offenders in this nonrecidivistic cohort had high scores. If R^+ for this age group was reported to be 8.8% per the RS-99 (see the intersection of the fifth row and the fourth column in the top panel of Table 1), $P(R^+ \mid S)$ for this cell in the new table would be 32% because

$P(S \mid R^+) = 20/77 = 0.260$,
$P(S \mid R^-) = 60/1{,}132 = 0.053$,
$LR^+ = .260/.053 = 4.91$,
$R^+/1{-}R^+ = 0.088/.912 = 0.096$,
Numerator of equation (3) = $0.096 \times 4.91 = 0.471$,
Denominator of equation (3) = $1 + .471 = 1.471$, and
$P(R^+ \mid S) = 0.471/1.471 = 0.320$.

5. Vrieze and Grove (2010), who refer to this principle as "the total relevant evidence requirement," state that it is

> Generally formulated as follows: In drawing conclusions about a matter of fact, one is required to base conclusions on all evidence that is probabilistically relevant to the

> conclusion . . . Relevant means here that the likelihood ratio . . . , conditioned on all other known facts with regard to recidivism over some defined time interval, does not equal 1.0.
>
> Total means that all facts for which the conditional likelihood ratio is other than 1.0 must be considered . . . In practice, one confines attention to facts for which one knows the conditional likelihood ratio to be materially different from 1.0 (p. 388).

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