Objective predictors of outcome in forensic mental health services—a systematic review

Ottilie Sedgwick,[1,2,3] * *Susan Young,*[2,4] *Mrigendra Das,*[2] *and Veena Kumari*[1,3]

[1] Department of Psychology, Institute of Psychiatry, Psychology & Neuroscience, King's College London, London, UK
[2] Broadmoor Hospital, West London Mental Health Trust, Berkshire, UK
[3] National Institute for Health Research Biomedical Research Centre for Mental Health, Institute of Psychiatry and South London and Maudsley NHS Trust, London, UK
[4] Centre for Mental Health, Faculty of Medicine, Imperial College London, London, UK

This systematic review aimed to examine whether neurobiological methods, or other methods independent of clinical judgment, have been investigated to assist decision making in forensic mental health services and, if so, whether this may be a useful strategy for predicting outcomes. OVID-Medline, Embase, and PsychInfo (inception–January 2015) were searched, limiting to English and human studies, using terms relating to "predict," "outcome," "psychiatry," and "forensic" to identify primary research articles reporting on predictors of outcome in forensic mental health services not reliant on clinical judgment/self-report. Fifty studies investigating demographic, neuropsychological/neurophysiological, and biological predictors were identified, reporting on 3 broad outcomes: (i) inpatient violence, (ii) length of stay, (iii) reoffending. Factors associated positively, negatively, and showing no relationship with each outcome were extracted and compiled across studies. Of various demographic predictors examined, the most consistent associations were between previous psychiatric admissions and inpatient violence; a more "severe" offense and a longer length of stay; and young age and reoffending. Poor performance on tests of cognitive control and social cognition predicted inpatient violence while a neurophysiological measure of impulsivity showed utility predicting reoffending. Serum cholesterol and creatine kinase emerged as biological factors with potential to predict future inpatient violence. Research in this field is in its infancy, but investigations conducted to date indicate that using objective markers is a promising strategy to predict clinically significant outcomes.

Introduction

Outcomes in forensic mental health services are varied and often poor. In 2007, around 50% of patients detained

under the legal category "psychopathic disorder" in the United Kingdom had a stay in a hospital exceeding 10 years.[1] Lengthy admissions were also identified in one German study that found that some patients stayed as long as 43 years.[2] Further, prospective follow-up studies of discharged mentally disordered offenders (MDOs) have shown a relatively high rate of reoffending, with 1 in 8 men being convicted for another grave offense after discharge from medium security services in the UK.[3] This has significant implications in terms of public protection, cost to the taxpayer, and the ethical position of detaining individuals for treatment, which may not be efficacious.

Current methods of predicting outcome include a multidisciplinary assessment of need (ie, criminogenic and clinical factors that require intervention), which often involves the use of structured professional judgment instruments to assess the level of risk,

generally in the context of treatment planning.[4,5] The Historical Clinical Risk Management (HCR-20)[6] scheme is an example of this, and has shown good predictive validity for future violence.[7] The psychopathy checklist (PCL-R) has grown in popularity as a quasi-risk-assessment tool due to the demonstrated link between high PCL-R scores and both inpatient violence and community reoffending.[8,9] However, while these assessment tools supersede unstructured clinical decision making,[10] they still rely on clinical judgment/decision making to draw conclusions. This is particularly relevant when considering the forensic population, many of whom are diagnosed with disorders that are characterized by deceptive behaviors [eg, antisocial personality disorder, taken from the *Diagnostic and Statistical Manual of Mental Disorders*, Fifth Edition (DSM-5): "Deceitfulness: dishonesty and fraudulence; misrepresentation of self; embellishment or fabrication when relating events."). Further, it is plausible that offenders may wish to present as low risk in order to secure early discharge, adding a further complication for clinicians making assessments of need.

A recent review[11] has identified wide variation in the rate of violence observed from those who are classified as "high-risk" using 9 of the most widely used risk assessment tools, both within and between risk assessment schemes. When considering this alongside evidence suggesting that there is very little change in HCR-20 scores across an individual's stay in a high-security hospital despite them engaging in risk-focused treatment, it calls into question the clinical utility and sensitivity of such tools. For example, Morrissey et al[12] found a change of 1 point or less (possible score range 0–10) in the dynamic clinical and risk scales, across 5 years. Although the clinical scale scores were significantly lower in the group about to be discharged compared to those who were still resident in the hospital, the risk scale and total scores were comparable, suggesting that these scales are either not sensitive enough to capture a reduction in risk, or that clinicians are not regarding this information as useful in their decision making about discharge.

A growing body of evidence has shown than an array of neurobiological factors is associated with violent behaviors in mentally disordered populations,[13-17] and it may be that some of these correlates could also assist clinicians working in forensic services to make decisions about treatment planning, risk, and discharge. Such factors, which are objective and measurable, reduce the likelihood of errors of judgment being made. Consideration of these factors alongside methods already employed could enhance the amount of information available, and thus potentially improve decision making or identify areas of outstanding need. This could theoretically lead to improved outcomes for patients, the public, and the taxpayer via more appropriate treatments being offered,

fewer premature discharges, and more efficient services, respectively.

This systematic review aimed to identify and evaluate studies that have assessed objective predictors of outcome in forensic mental health services (ie, did not rely on self-report or clinical judgment) to gain a perspective on how far these correlates have been used by the scientific and clinical community, and to assess the potential usefulness of such markers in further research and subsequently in clinical practice.

Method

OVID-Medline, Embase, and PsychInfo (inception–January 2015) databases were searched using the following 4 terms combined with AND:

1. predict* OR prognos* or marker
2. outcome OR length of stay OR duration of stay OR length of hospitalization OR duration of hospitalization OR reoffen* OR recidiv* OR violen* OR function*
3. mental disorder OR psychiatr* OR mental ill*
4. forensic OR secur* OR incarcerated

A screen of the results for relevance was then conducted on a title/abstract basis. If insufficient information was given in the abstract, the full text was retrieved before making a decision. Studies were assessed for inclusion against the following criteria:

1. All participants were MDOs admitted to inpatient forensic psychiatric services. For the purposes of this review, an MDO is defined as an offender with a diagnosed mental disorder, who is deemed to require treatment in psychiatric services. Individuals residing in prison who have a mental disorder were not included, as it is highly likely that individuals who are deemed treatable within prison (as opposed to secure psychiatric hospitals) are qualitatively different. Further, "specialist" offender groups (adolescents, eg, Letourneau and Armstrong[18]; learning disability, eg, Bastert et al[19]) were excluded to keep the study samples as homogeneous as possible.
2. We accepted studies that included an objective predictor of outcome (as defined as a factor that does not rely on clinical judgment or self-report, eg, biological, neuropsychological, demographic factors), with outcome defined as one of the following: length of stay, violent incidents (inpatient or community), functioning, clinician-rated risk/need.
3. Only primary research articles with an abstract were included (eg, not theses or reviews). The reference lists of relevant reviews were examined to identify any papers not returned by the initial search.
4. Studies were only included if they used a prospective, or pseudo-prospective, design (ie, looking forward

over time) to assess predictive ability. Studies that reported on the ability of static (ie, demographic) factors to predict outcome were also included; these did not necessarily need to be prospective, as static factors by definition are temporally stable.

5. Studies were excluded if they were reviewing the predictive validity of risk assessment tools. This literature is large and robust and has been reviewed elsewhere.[20-22] Further, these tools require the assessment of a combination of demographic and clinical factors that may relate to risk collectively, but often individual item predictive validity is not given.

6. Articles referring solely to competency to stand trial were also excluded. This intervention involves treating the underlying disorder and educating the individual about the American legal system so that they are able to stand trial[23]; it is not analogous with the typical treatment MDOs receive (ie, the focus is to restore competency).

Data extraction

For each study, predictors associated positively with the outcome variable of interest (eg, associated with an increased likelihood of violence), predictors with a negative association (eg, associated with a decreased likelihood of violence), and examined variables with no relationship (eg, no relationship to violence) were extracted. Studies were examined, and any factors identified by the authors as "statistically significant" were extracted. This included significant differences between relevant groups (eg, between reoffenders and non-reoffenders) and significant positive or negative predictors of outcome. Variables that were examined by the authors but had no significant effects were included in the "no relationship" category.

Predictor variables were then compiled into a spreadsheet, and studies that reported on the same broad predictors for the outcome of interest were recorded. Categories that were conceptually similar but perhaps not described in the exact same terms (for example, "severity of offense" and "a violent or homicide offense") were combined to reduce the number of discrete predictors.

Results

The search returned 1896 results. See Figure 1 for the flowchart of study selection.

Fifty articles, which included data on objective predictors of outcome in forensic mental health services, were retained in the final review. Studies were categorized into 3 broad outcome groups: those reporting on predictors of (1) inpatient violence, (2) length of stay in forensic inpatient services, and (3) community reoffending. Further, the types of predictor could also be delineated into 3 categories. These were (i) demographic

(42 studies), (ii) neuropsychological/neurophysiological (4 studies), and (iii) biological (4 studies) predictors. The term "demographic" is used here as a broad, all-encompassing term to refer to static, historical factors, including clinical, offense-related, developmental, institutional, and sociodemographic factors.

Predictors of inpatient violence

Demographic predictors

Thirty-eight separate demographic factors across 8 studies[24-31] were identified as predictors of inpatient violence (Table 1). Of these, 16 factors were considered in more than 1 study. Only 1 factor, previous psychiatric admissions, was found to be associated with inpatient violence in the majority of studies that examined it; 2 studies found a positive relationship between number of previous psychiatric admissions and inpatient violence,[24,31] whereas 1 study found a null effect.[28] One of these studies assessed seclusion episodes as opposed to inpatient violence directly[31]; however, all seclusion incidents were related to aggressive behavior, apart from 1 episode of self-harm.

Another demographic factor, young age, was examined by 6 studies, of which 3 found a positive association[27,29,31] and 3 found no association.[24,25,28] Similarly, a history of violence was found to be associated with inpatient violence in 2 studies,[24,28] and not associated in 3 studies.[29-31]

Other factors examined by 2 or more studies and found to be unrelated to inpatient violence are listed in Figure 2. Notably, a history of substance use,[27,28,30,31] diagnosis,[24,31] and gender[24,28,30,31] did not emerge as consistent predictors across studies (Figure 2).

Neuropsychological predictors

One study[32] reported the ability of neuropsychological assessments to predict aggression among 23 male forensic inpatients (n = 16 with a principal diagnosis of schizophrenia). Aggressive behavior was monitored over the year following testing using the Overt Aggression Scale.[33] The results demonstrated that poor visuospatial processing [assessed by the Judgment of Line Orientation Test (JLOT)[34]], poor cognitive inhibition [scores on the Stroop Color/Word Test (SCWT)[35]], and the number of misperceptions of an angry voice in an emotional recognition test could reliably predict the frequency of subsequent aggression. Scores from the JLOT and SCWT were also significantly correlated with the severity of aggression.

A similar study[36] reported a 5-week follow-up of 10 forensic inpatients. Contrary to expectation, performance on a measure of behavioral inhibition (the Stop Task[37]) was better at a trend level among those who were

```
            ┌─────────────────┐
            │  1896 articles  │
            └────────┬────────┘
                     │              Deduplication
                     │    856 →     Limit to Human, English Language
                     │              Non-Peer Reviewed
                     │              No Abstract
            ┌────────┴────────┐
            │  1040 articles  │
            └────────┬────────┘
                     │
                     │    831 →     Title/Abstract Suggests No Relevance
                     │
            ┌────────┴────────┐
            │  209 articles   │
            └────────┬────────┘
                     │              71 – Risk assessment tools
                     │              31 – Not MDO
                     │    165 →     26 – Not prospective/outcome data not reported
  5 articles from    │              14 – Self/clinician report
  hand searching  →  │              10 – Review articles
                     │              6 – Competency restoration
                     │              3 – Clinical decision making
                     │              1 – Compared hospitals
                     │              1 – Reported on community treatment
                     │              1 –Factors only relevant post discharge
            ┌────────┴────────┐     1 – not in English
            │   50 articles   │
            └───┬────┬────┬───┘
```
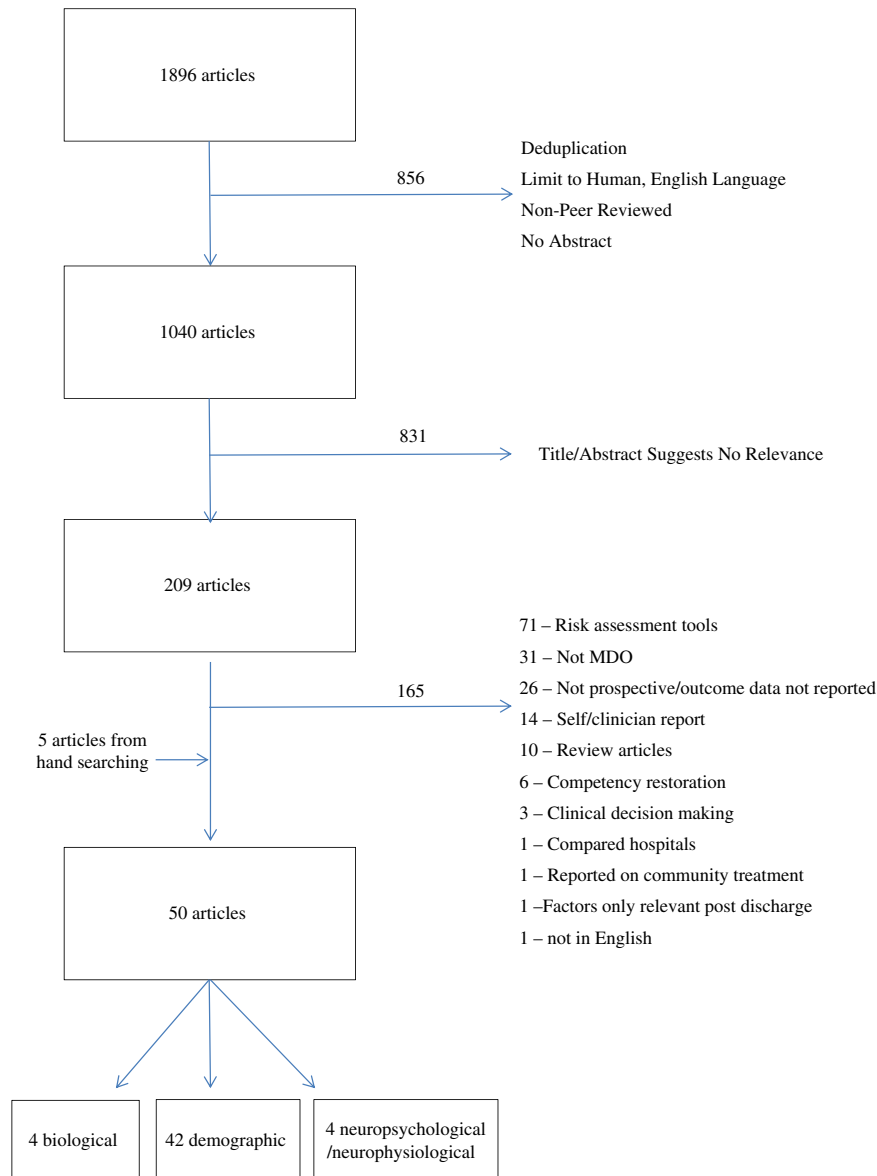
FIGURE 1. Flowchart of study selection.

involved in aggressive incidents compared to those who were not, suggesting that those who were more impulsive were involved in fewer incidents. However, this study was significantly limited by its small sample size and low rate of recorded incidents (12 incidents, conducted by 5 patients), and thus the results must be interpreted with caution. In addition, no information regarding diagnosis is given by this study, leaving questions as to the generalizability of the results to other populations.

A further study[38] examined clinical outcome, need, and risk, which are all facets sensitive to inpatient violence, in a high-security hospital. Thirty newly admitted men with schizophrenia were assessed on a number of neuropsychological tasks, including an assessment of IQ, processing speed, and working memory using the Wechsler Adult Intelligence Scales,[39] in addition to the Trail Making Test[40] and the SCWT.[35] Further, 2 social cognitive tasks were conducted, the Revised Eyes Task [41] and a Modified Advanced Theory of Mind Test.[42] Outcome measures included the Health of the Nation Scales–Secure version (HoNOS), the Camberwell Assessment of Need–Forensic version (CANFOR), and the HCR-20, which assess clinical, social, and functional outcome; need; and risk, respectively, at 3-year follow-up. Although a number of nonsocial cognitive tasks showed utility in predicting some outcomes of interest (eg, Trail Making part B was significantly correlated with scales from the HoNOS, the total CANFOR score, and HCR-20 risk management scale), the overwhelmingly most predictive test was the

TABLE 1. Demographic predictors and their association with inpatient violence

Clinical predictors		Offence-related predictors		Developmental predictors		Institutional predictors		Sociodemographic predictors	
ASPD	1/1	History of sexual offending	0/1	Childhood history of abuse/neglect	0/1	Ability to follow ward routine	0/1	Combat experience	0/2
Borderline symptoms	1/1	History of violence	2/5	Education	0/1	History of escape	0/1	Employment	0/1
Command hallucinations	0/1	Index crime characteristics	0/2	"Family deviance," eg, parental alcohol/drug use	0/2	Longer length of stay	1/1	Female gender	1/4
Depressive symptoms	0/1*	Legal status	1/4			Number of previous forensic psychiatric admissions	0/2	Race	1/3
Diagnosis	0/2	Previous offences	1/4			Previous psychiatric admissions	2/3	Religion	0/1
Dual diagnosis (schizophrenia and SUD)	1/1	Young age at first arrest	0/1			Transferred prisoner	1/1	Single	0/3
Early onset mental health problems	1/1	Young age at index offence	0/1			Young age at first psychiatric hospitalization	0/1		
Neurologic abnormality	0/1					Young age on admission	3/6		
Paranoid delusions	0/1								
PD (excluding ASPD)	0/1								
Positive psychotic symptoms	1/1								
Schizophrenia	0/2*								
Self-injurious behaviour/suicide attempt	1/2								
Substance use	1/4*								

ASPD: antisocial personality disorder; PD: personality disorder; SUD: substance use disorder.

Table gives number of studies with a positive relationship to inpatient violence, over the number of studies examining this factor. Factors with * include some studies which suggest a negative effect, ie, the factor in question is associated with reduced inpatient violence (exact figures are presented in Figure 2).
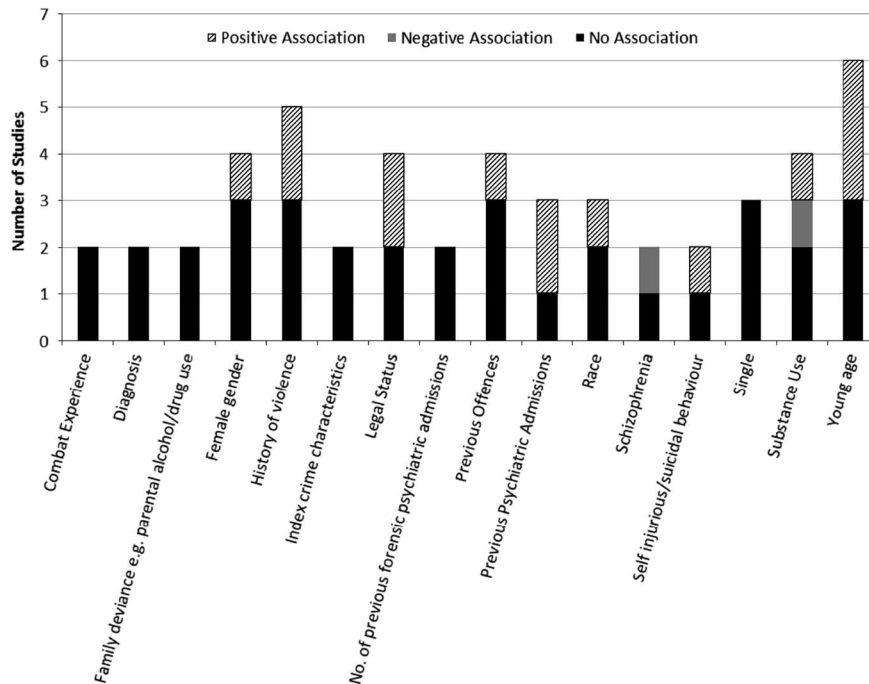
FIGURE 2. Demographic predictors examined by at least 2 studies and their association with inpatient violence.

Revised Eyes Test. After controlling for all other variables, the Revised Eyes Test score could significantly predict total CANFOR score, the risk management score on the HCR-20, and the social scale score of the HoNOS.

Thus, patients with schizophrenia who were less able to interpret emotional information from the eyes were likely to have higher ratings of unmet need, poorer social functioning, and a higher level of assessed risk. This may be relevant to the Violence Inhibition Mechanism theory,[43] according to which poor interpretation of negative facial expression removes inhibitory influences that serve to stop violent behavior through negative reinforcement of the unwanted (aggressive) behavior. Poor theory of mind may also reduce the capacity for cognitive empathy[44] or understanding typical social rules,[45] which could lead to social conflict and potentially violent behavior.

Finally, one demographic study extracted evidence of "cognitive impairment" (present/absent) from patient files, and found that this was a significant predictor of frequent violent behavior among inpatients.[28] Although there is not detailed explanation of the nature or severity of cognitive impairment in these participants, this study supports the assertion that cognitive dysfunction may be related to aggressive behaviors.

Biological predictors

Four studies[46–49] examined biological predictors of inpatient violence, although 3 of these studies[46,47,49]

were conducted within the same sample. Two[46,48] related to serum cholesterol levels, while 2[47,49] were concerned with creatine kinase elevations.

Serum cholesterol. The serum cholesterol levels of 106 forensic inpatients at admission were examined, and subsequent aggressive incidents toward others or themselves over the following 2 years (pseudo-prospective review of medical records) were followed up.[46] The sample was divided into high ($\geq$200 mg/dl) and low (<200 mg/dl) cholesterol groups, and the difference in aggressive incidents (frequency, severity, and type) was investigated. While the 2 groups did not differ with regard to severity or type of aggression, the frequency of aggression in the low cholesterol group was significantly increased. Interestingly, the relationship between cholesterol level and frequency of aggression was nonlinear, with aggression being most frequent within the range 160–170 mg/dl.

A similar investigation[48] was conducted in order to determine an optimum cut-off point for predicting aggression using serum cholesterol levels. Using male participants detained in a forensic hospital, the sample was divided into those who had been secluded at least once over a 28-month period (n = 195) and those who had not been secluded (n = 202). When comparing these groups, the secluded group had significantly lower total serum cholesterol. Using receiver operating characteristic analysis, the optimum cut-off for predicting those who would be secluded for any reason was 5.3 mmol/l. However, for patients who spent a longer duration of their

detention in seclusion for aggression/self-harm, perhaps considered the most frequently aggressive patients, the optimum cut off was 4.3 mmol/l. When converted into mg/dl (as used in the previous investigation), this equates to approximately 165 mg/dl, which is highly consistent with the 160–170 mg/dl range found for the most frequently violent patients in the aforementioned study.[46] The difference in cholesterol level between the 2 groups was independent of body mass index and medication.

Creatine kinase. One study[47] investigated the predictive utility of creatine kinase (CK) as a marker of aggressive behavior in 164 male forensic inpatients, again using a pseudo-prospective design. CK is an enzyme involved in in-situ energy production in cells.[50] The sample was divided into high or low aggression, based on a median split procedure on scores for the severity, frequency, and type of violence as determined by the Overt Aggression Scale (verbal vs physical). In all 3 comparisons (severity, frequency, and type), the CK levels were significantly higher in those who were more frequently violent, engaged in more severe violence, and in those who used physical as opposed to verbal aggression.

An association between assaultiveness and use of restraint prior to CK levels being determined was also observed. Those who had been assaultive during their admission and those who had been restrained had higher observed CK levels than those who had not. Importantly, a significant interaction between these factors was observed, in that those who were assaultive/restrained and then engaged in subsequent violence had significantly increased CK levels (around a 5-fold increase) during their admission compared to those who were assaultive/restrained and then not violent. This suggests that, of those patients who present management problems during their admission, the likelihood of subsequent aggression can be gauged by assessing CK levels. These findings were irrespective of diagnosis, recent physical exercise, recent accidents, or recent intramuscular medication. However, 2 caveats were noted: (1) these findings were only significant in those patients taking antipsychotic medication, and (2) CK levels were not sensitive to change in aggression, ie, they did not increase prior to an aggressive incident, nor decrease afterward. Despite this, the authors assert that using a >200 U/l cut-off could correctly predict future assaults in 94% of cases, compared to using prior assaultiveness alone as a predictor (64%).

A further study on the same sample[49] examined CK as a function of ethnicity and aggression. While the results demonstrated that CK levels were higher in African Americans than in Caucasians, and that African Americans were more likely to be physically aggressive compared to Caucasians, the increased levels of CK observed in African Americans was still significant even when the effect of aggression was covaried out.

Predictors of length of stay

Demographic predictors

A total of 44 diverse predictors were examined in relation to length of stay, with 25 of these being examined by more than one study (Figure 3). The factor that most studies examined was severity of offense. Unsurprisingly, 9[2,51–58] out of 10[59] studies found that a more "severe" offense was related to a longer length of stay. This is supported by 2 studies that examined the effect of a restriction order on length of stay (administered to patients in the UK who are considered to be particularly high risk), which both showed a lengthening effect.[58,60] Three studies[53,54,57] found that having a psychotic disorder was associated with a longer length of stay, although 1 study found the opposite (shorter stay),[59] and 1 found no significant effect.[58] In addition, 3 studies found no effect for "diagnosis" on length of stay (which included psychosis)[52,55,56]; however, it is notable that in 2 of these studies, there was a very small proportion of offenders not diagnosed with a psychotic illness, suggesting limited sensitivity to find an effect. Two out of 3 studies that examined absconding during hospitalization found that this was associated with a longer stay.[2,61]

Previous offenses was found to be unrelated to length of stay in all 6 studies that examined this,[2,51,52,55–57], which provides strong evidence that it is the severity, as opposed to the extent, of offending which is implicated in how long MDOs remain in services. Other examined factors for which no clear association emerged are detailed in Figure 3 and Table S2 (available online in the Supplementary Material).

Neuropsychological/neurophysiological and biological predictors

No studies examining the effect of neuropsychological/neurophysiological or biological variables on length of stay were identified.

Predictors of community reoffending

Demographic predictors

Community reoffending, encapsulating re-arrest, readmission, recidivism, etc, was the outcome of interest in the majority of the articles (n = 25). Again, a large and diverse number of factors (total 66) was considered across studies (Table 2), with 27 factors only considered in a single study. The most frequently examined predictor was previous offending, which was examined by 18 studies.[3,52,54,55,61–74] Of the studies that examined previous offending, 67% found an association with reoffending. Young age at admission or discharge was investigated in 15 studies,[3,26,52,54,55,62–67,69,73,75,76] with 67% finding a positive effect, while the effect of a shorter length of stay was examined in 12
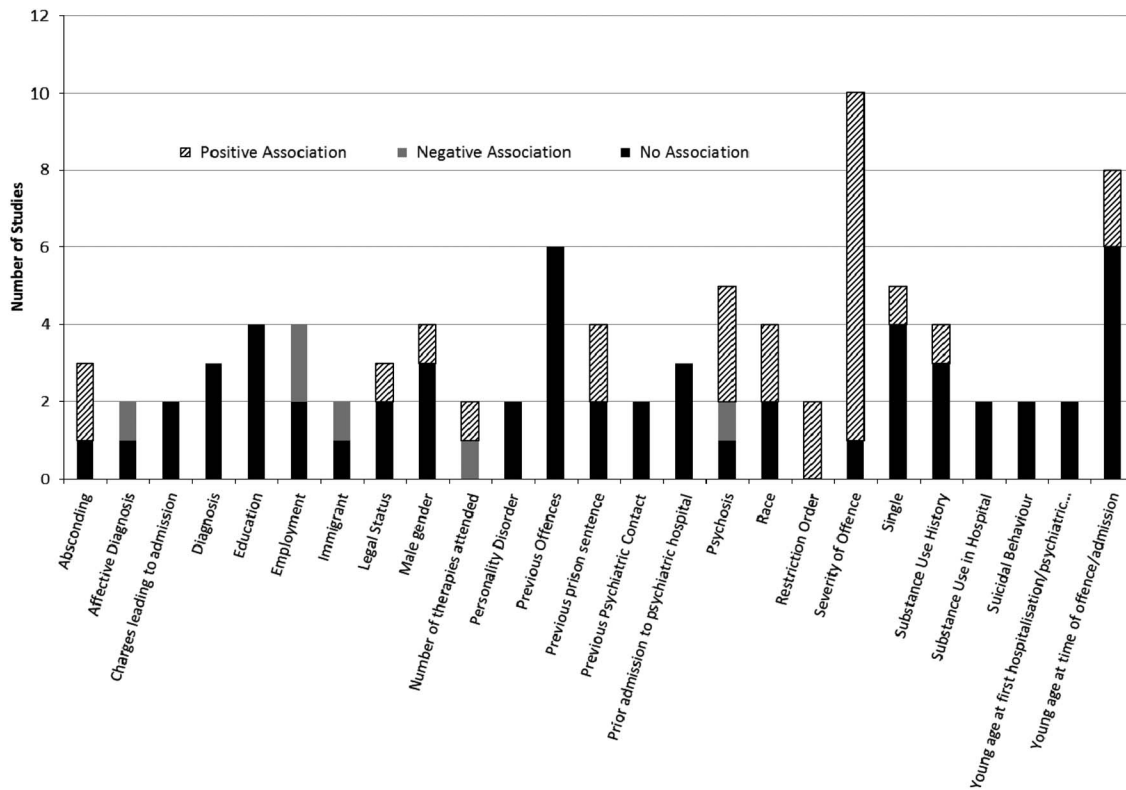
FIGURE 3. Demographic predictors examined by at least 2 studies and their association with length of stay.

studies,[3,55,62,66–68,70,73–77] and 50% found that it was associated with reoffending.

Male gender,[3,52,55,63,64,67,69,73,76,77] race,[3,52,55,62,65–67,69,76,78] and being single[3,54,62,65,69–72,75,77] were investigated in 10 studies each, with positive findings indicated in 40%, 20%, and 30%, of studies, respectively. Other frequently examined factors included previous violence (9 studies,[55,66–68,70–72,77,79] 44% positive finding), young age at time of offense (8 studies,[3,52,65,68,69,71,72,74] 50% positive finding), employment (8 studies[54,68,70–72,74,75,79]; 34% found that it was negatively associated with reoffending, and the remainder found no association), previous psychiatric admissions (10 studies,[62,67,69–76] 10% found positive effect), and substance use (7 studies,[3,62,65,71,75,76,80] 43% positive finding).

In terms of diagnostic groups, personality disorder (PD) was examined by 9 studies,[3,68–72,75,80,81] with 78% of studies finding a positive association with reoffending. Six studies examined psychosis,[54,62,68,71,74,75] with 50% finding that this was negatively associated, and the remainder finding no association with reoffending. However, 4 studies[52,55,66,67] found that "diagnosis" as a predictor (encapsulating PD and psychosis) was unrelated to reoffending, somewhat weakening these initially strong findings. This differential pattern of results likely reflects the diagnostic homogeneity of

these 4 studies, in which the vast majority of patients had psychotic disorders and only small numbers were diagnosed with personality disorder (8%, 8%, 13%, and 9%, respectively), whereas studies that had more variance in diagnostic group, and thus more power to detect significant differences, tended to find positive results. For example, in a sample in which the number of participants with PD or psychosis was approximately equivalent,[81] PD emerged as a factor associated with reoffending.

In addition, 1 study[82] that examined "success of transfer" from high security to medium security found no significant demographic predictors. This outcome was deemed conceptually distinct from any of the 3 main outcome groups (as an unsuccessful transfer could be due to inpatient violence or worsening of symptoms, for example), and thus the predictors were not included in the variable count. A list of the variables examined in this study is included in Table S1.

Neuropsychological and neurophysiological predictors

Six demographic studies examined the effect of IQ on reoffending.[70–72,74,75,79] It is notable, however, that these studies did not conduct a formal assessment of IQ; scores were extracted from patient files, which may have limited the findings in terms of standardizing the

TABLE 2. Demographic predictors and their association with recidivism (reoffending/rearrest/readmission)

Clinical predictors		Offense-related predictors		Developmental predictors		Institutional predictors		Sociodemographic predictors	
Comorbid SUD and PD	1/1	History of recidivism	0/1	Bed wetting	0/1	Admitted for assessment	0/1	Employment	0/8*
Delusional disorder	0/1	History of sexual offending	3/4	Childhood abuse/trauma	0/2	Civilly committed	1/2	Homosexuality	0/1
Depression	0/2*	More admissions to corrections	2/3	Childhood fighting or bullying	1/2	Criminally committed	1/1	Male gender	4/10
Diagnosis	0/4	Offense characteristics	1/4	Childhood foster care	1/1	Detained under psychopathic disorder	3/4	Race	2/10
Mood/affective disorder	1/1	Previous conviction for property crime	3/4	Cruelty to animals in childhood	1/1	Inpatient violence	0/3	Relationship prior to admission	0/1*
Organic/cognitive disorder	0/1	Previous offenses	12/18	Early birth order	1/1	Known to institutions	1/1	SES	0/1
PD	7/9	Previous prison sentence	2/3	Education	0/6	Longer time in institutions	1/1	Single	3/10
Poor compliance with medication	1/1	Previous violence	4/9	Firesetting (childhood)	0/1	Number of times absent without leave	1/1	Young age at admission/discharge	10/15
Psychosis	0/6*	Severity of index offense	2/5	History of CD	1/1	Previous psychiatric admissions	1/10		
Sexual deviation	0/1	Unfit to stand trial	0/1*	Institutionalization in childhood	2/3	Previous psychiatric treatment	0/3		
Substance use	3/7	Victim characteristics	0/3	Lived with parents until 16	0/3	Previous secure psychiatric care	0/2		
		Young age at time of offense	4/8	Low family SES (childhood)	1/1	Reason for readmission	0/1		
				Parental absence	2/4	Referral source	1/4		
				Parental crime/alcohol abuse	1/2	Restriction order/conditional discharge	0/5*		
				Parental psychiatric history	0/1	Seclusion during admission	0/2		
				School maladjustment/expulsion	1/3	Shorter length of stay	6/12		
				Teen alcohol abuse	1/1	Sexually inappropriate behaviour (inpatient)	0/1		
				Young age at onset of mental disorder	1/3				

SUD: substance use disorder; PD: personality disorder; CD: conduct disorder; SES: socio-economic status.

Table gives number of studies with a positive relationship to reoffending/rearrest/readmission, over the number of studies examining this factor. Factors with * include some studies which suggest a negative effect, ie, the factor in question is associated with a reduced likelihood of recidivism (exact figures given in Figure 4).
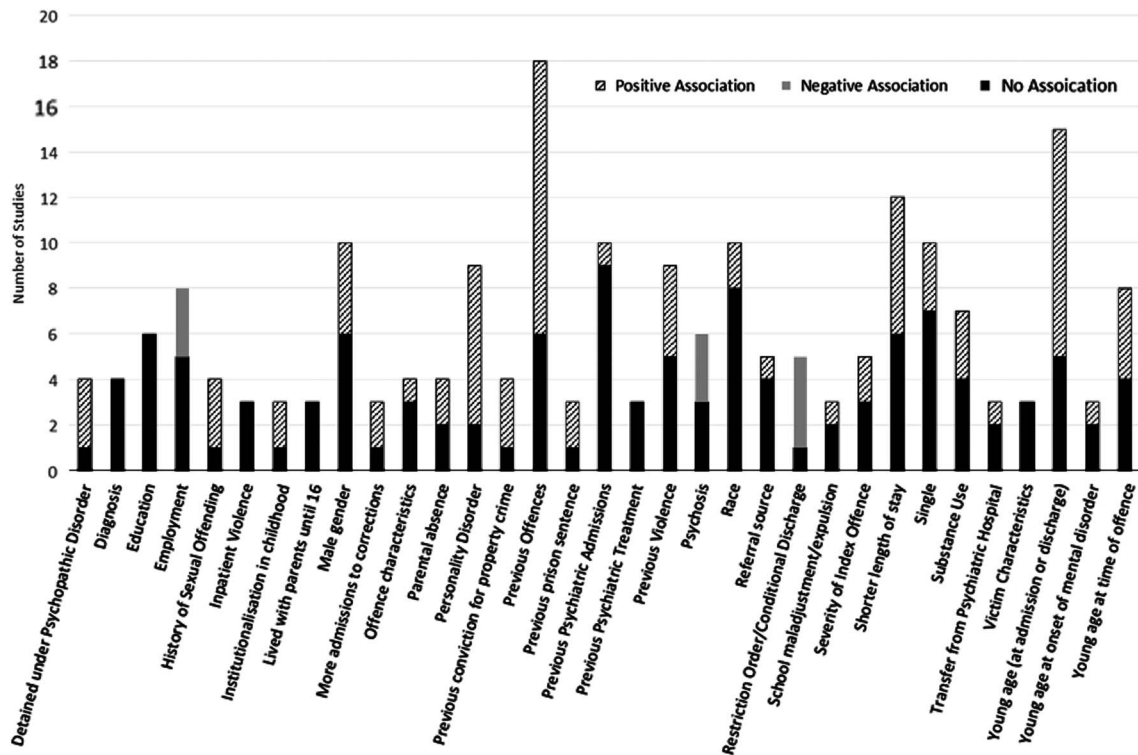
FIGURE 4. Demographic predictors examined by at least 3 studies and their association with reoffending/rearrest/readmission.

assessment tool used. Further variation may also have been introduced in terms of when the assessment was conducted (ie, at admission, during an acute phase of illness, during court proceedings, etc), which was not evident from the reviewed papers. Five of these investigations found no relation to reoffending,[70–72,74,75] while one study found a positive association (ie, those with lower IQ were more likely to reoffend).[79]

Howard and Lumsden[83] assessed the relationship between the contingent negative variation (CNV) event-related potential during a go/no-go task and community reoffending in a sample of 44 admissions to a high-secure forensic hospital. The CNV during this task has been correlated with measures of impulsivity[84] and has been used as evidence of pathological impulsivity in court proceedings.[85] Thus, it can be considered an objective measure of behavioral impulsivity. Based on the CNV results obtained, patients were classified as high or low risk depending on whether their score was 1 standard deviation outside or within a control group's score, respectively. At 15 years post-testing, criminal records were examined to reveal that 6 of 21 in the high risk group had been convicted of another offense, including manslaughter, burglary, and arson. This compares with only 1 of 23 in the low risk group, convicted of theft. Thus, it appeared that using the CNV during go/no-go was sensitive to differentiating those who may reoffend, and appeared to identify those at risk of committing

more serious offenses. The authors assert that the overall predictive accuracy was 63.6% and the relative improvement over chance was 72%.

Biological predictors

No studies examining the effect of biological variables on community reoffending were identified.

Discussion

This systematic review of objective factors relating to outcomes in forensic mental health services is, to our knowledge, the first review of such factors to be conducted.

In terms of demographic factors, the predictors of inpatient violence included previous psychiatric admissions (67% positive finding), with mixed findings for young age (50% found an association with inpatient violence). Demographic factors associated with an increased length of stay included the severity of the index offense (90% positive finding) and having a history of absconding (67% positive finding). Initially, psychosis appeared to be associated with an increased length of stay; however, once studies examining "diagnosis" as a predictor more broadly were considered, this association was weakened, probably due to sample diagnostic homogeneity, as a low number patients included in these studies were not diagnosed with psychosis. Our findings

relating to reoffending suggest previous offending, young age at admission or discharge, and personality disorder are relatively robust predictors of recidivism, with the large majority of studies examining each factor indicating a positive association. The majority of studies that examined psychosis found that this had no relationship with future offending, perhaps reflecting the relative efficacy of treatments that are available for psychotic disorders in comparison to personality disorder.

This review may have been limited in its ability to examine demographic predictors of outcome, as it excluded articles relating to risk assessment tools, which focus on this type of predictor. Structured professional judgment tools such as the HCR-20[6] include items such as young age, identified by this review to be related to future offending, suggesting that they do hold useful predictive properties. However, many factors identified in this review showed conflicting results. For example, young age was found to be associated, and also not associated, with inpatient violence in an equal number of studies, just as a previous prison sentence was found to increase the length of stay in 2 studies, but found to be unrelated in 2 further studies. This suggests that demographic factors in isolation are not particularly useful to clinicians in assisting decision making, but may perhaps hold more validity when considered in combination (as risk assessment tools advocate).

In addition, demographic factors are static and thus not sensitive to changing risk, which may be picked up by indices of neurological or biological function. A further limitation relating to the demographic results is that combining similar, but perhaps slightly different, demographic factors (eg, "severity of offense" and "a violent or homicide offense"), may have somewhat distorted the true relationship between a given predictor and outcome. Future research should aim to operationalize predictor variable definitions to aid in the understanding of the unique contributions each predictor makes. This criticism also holds in relation to the definitions of outcome. For example, inpatient violence often has broad and differing conceptualizations in research investigations,[86] and although the majority of articles included in this review included episodes of both verbal and physical aggression in this outcome category, some excluded verbal threats[27] and some included specific operationalizations such as "throwing food or an object that strikes another person."[23] Length of stay may also have different implications across countries. For example, in the UK, length of stay is linked to clinical responsiveness. Patients admitted under a hospital order are able to move from hospital to conditions of lesser security once they are deemed to have responded to treatment and reduced their level of risk. However, this may not be the case in other countries, such as the USA,

where fixed-length sentences may have been imposed. In this review, one-third of studies examining length of stay were conducted in the USA, with 50% conducted in Europe and 17% in Australasia. To allow greater insights into our findings, information about the location of individual studies has been included in Table S1.

Common themes emerged from the identified neuropsychological and neurophysiological predictors. Impulsivity as assessed by the contingent negative variation event-related potential was associated with future reoffending upon discharge,[83] and SCWT errors (poor cognitive inhibition)[32] were associated with increased frequency and severity of inpatient violence. Both of these facets could be considered to reflect poor behavioral controls, and thus this may be an area that merits further research in relation to its utility as a marker of violence or reoffending. One study included in this review[36] did not support this assertion; however, as previously discussed, it was underpowered, with a very short follow-up period and a low rate of inpatient violence was observed. Poor social cognition emerged from 2 studies as a robust marker of outcome.[32,38] Misperception of angry voices was found to be associated with inpatient violence, and another study identified poor reading of emotion from the revised eyes task to be the overwhelmingly best predictor of risk and unmet need at follow-up. These results indicate that both cognitive and social-cognitive deficits appear to be associated with outcome, and could be targets for effective treatment.

The strategy of using neuropsychological tests to predict outcome is strengthened by other, nonprospective studies not included in this review. For example, it was shown that scores from the Iowa Gambling Task[87] could be used effectively to predict whether MDOs had been secluded in the past for either predatory or impulsive violent acts while in secure mental health services.[88] However, 1 cross-sectional study[89] found no significant association between neuropsychological measures and previous inpatient violence in 82 violent men with schizophrenia (including the National Adult Reading Test,[90] the Wechsler Abbreviated Scale of Intelligence,[91] Stop Task,[92] and the CANTAB-2 battery[93]), although current and predicted IQ tended to correlate negatively with the number of violent incidents across an individual's time in the hospital, suggesting that there may be a role for neuropsychological function in the emergence of violent behavior. More prospective studies are required to fully elucidate relationships such as these.

The use of biological markers to assist in clinical decision making also appears to have support from the reviewed studies. Both serum cholesterol and creatine kinase appeared able to predict inpatient violence to a reasonable degree of accuracy. Low serum cholesterol has

been linked to higher rates of death from violence or suicide,[94] and experimentally lowered cholesterol has been linked to aggressive behavior in animals.[95] A putative mechanism of action suggests that low cholesterol reduces the integrity of cell membranes, making serotonin receptors less efficacious, and poor serotonergic transmission has been linked to violent behavior.[95] Serum cholesterol as a marker has shown great promise in another prospective study of nonforensic inpatients; total cholesterol had a significant negative relationship with inpatient suicidal and violent behavior, and with 3-month post-discharge violent behavior.[96] This is an area for future research and development with strong potential.

A number of other studies, not included in this review due to the samples being referred for "forensic psychiatric evaluation" as opposed to admitted to services, have also investigated biological markers and show some promise. For example, one study[97] found that 27% of variance in reoffending could be explained by low non-oxidative glucose metabolism in a sample of violent offenders referred for evaluation and followed up 8 years later. Another study[98] showed that high levels of the thyroxine hormone triiodothyronine were associated with relapse into offending in another cohort of offenders referred for psychiatric examination. The use of these markers to predict other outcomes such as inpatient violence in individuals specifically detained in forensic mental health services is an area to be explored further.

The use of biomarkers to predict complex behavioral outcomes such as aggression or reoffending requires ethical consideration. Biomarkers in psychiatry have been subject to ethical scrutiny, namely for reasons including over-simplification of multifaceted and complex conditions, and by shifting the focus of "risk" to the individual as opposed to considering the wider societal contributing factors.[99] These issues are relevant to MDOs, and further work in this area should be mindful of the wider implications of the findings. Certainly at this early stage, putative biomarker predictors should be considered alongside clinical judgment and other predisposing factors such as personality pathology. There are also scientific issues to be resolved before the use of biological markers can be condoned. For example, an acceptable level of sensitivity and specificity would need to be established for any putative marker, and this would need to add incremental validity to any risk assessments that are currently in practice. An idea of the temporal stability would also be required, i.e., over what time frame does this marker suggest a risk? Interactions with medications and the "trait" vs "state" status of any biomarker would be further considerations before widespread use could be advocated.

In conclusion, the findings of this review suggest that using neuropsychological, neurophysiological, and biological markers to inform outcome is a feasible and potentially useful strategy. However, development of such markers is in its infancy, and further research in this field is required to translate these findings to clinical practice. Initial replication of the promising, small-scale studies identified in this review is needed and, if successful, large prospective cohort studies would be essential to establish the merit of such a strategy. Once developed, adding empirical markers such as these to clinical decision-making tools may be a beneficial strategy in the future to improve outcomes for MDOs, who are a group at present experiencing lengthy admissions to psychiatric care and poor outcomes in terms of reoffending. Thus, innovation in this area is essential.

Disclosures

The authors do not have anything to disclose.

Supplementary material

To view supplementary material for this article, please visit http://dx.doi.org/10.1017/S1092852915000723

REFERENCES:

1. Rutherford M, Duggan S. *Forensic Mental Health Services: Facts and Figures on Current Provision*. London: The Sainsbury Centre for Mental Health; 2007.
2. Ross T, Querengasser J, Fontao MI, Hoffmann K. Predicting discharge in forensic psychiatry: the legal and psychosocial factors associated with long and short stays in forensic psychiatric hospitals. *Int J Law Psychiatry*. 2012; **35**(3): 213–221.
3. Coid J, Hickey N, Kahtan N, Zhang T, Yang M. Patients discharged from medium secure forensic psychiatry services: reconvictions and risk factors. *Br J Psychiatry*. 2007; **190**(3): 223–229.
4. Glorney E, Perkins D, Adshead G, *et al*. Domains of need in a high secure hospital setting: a model for streamlining care and reducing length of stay. *International Journal of Forensic Mental Health*. 2010; **9**(2): 138–148.
5. Gudjonsson GH, Young S. The role and scope of forensic clinical psychology in secure unit provisions: a proposed service model for psychological therapies. *Journal of Forensic Psychiatry & Psychology*. 2007; **18**(4): 534–556.
6. Webster C, Douglas K, Eaves D, Hart S. *HCR-20 Assessing Risk for Violence* Version 2 Burnaby, BC: Mental Health, Law and Policy Institute, Simon Fraser University; 1997.
7. O'Shea LE, Mitchell AE, Picchioni MM, Dickens GL. Moderators of the predictive efficacy of the Historical, Clinical and Risk Management-20 for aggression in psychiatric facilities: systematic review and meta-analysis. *Aggression and Violent Behavior*. 2013; **18**(2): 255–270.
8. Hare RD, Clark D, Grann M, Thornton D. Psychopathy and the predictive validity of the PCL-R: an international perspective. *Behav Sci Law*. 2000; **18**(5): 623–645.
9. Walters GD. Predicting institutional adjustment and recidivism with the psychopathy checklist factor scores: a meta-analysis. *Law Hum Behav*. 2003; **27**(5): 541–558.

10. Hanson RK, Morton-Bourgon KE. The accuracy of recidivism risk assessments for sexual offenders: a meta-analysis of 118 prediction studies. *Psychol Assess*. 2009; **21**(1): 1–21.

11. Singh JP, Fazel S, Gueorguieva R, Buchanan A. Rates of violence in patients classified as high risk by structured risk assessment instruments. *Br J Psychiatry*. 2014; **204**(3): 180–187.

12. Morrissey C, Beeley C, Milton J. Longitudinal HCR-20 scores in a high-secure psychiatric hospital. *Crim Behav Ment Health*. 2014; **24**(3): 169–180.

13. Barkataki I, Kumari V, Das M, et al. A neuropsychological investigation into violence and mental illness. *Schizophr Res*. 2005; **74**(1): 1–13.

14. Barkataki I, Kumari V, Das M, Sumich A, Taylor P, Sharma T. Neural correlates of deficient response inhibition in mentally disordered violent individuals. *Behav Sci Law*. 2008; **26**(1): 51–64.

15. Kumari V, Aasen I, Taylor P, et al. Neural dysfunction and violence in schizophrenia: an fMRI investigation. *Schizophr Res*. 2006; **84**(1): 144–164.

16. Kumari V, Das M, Hodgins S, et al. Association between violent behaviour and impaired prepulse inhibition of the startle response in antisocial personality disorder and schizophrenia. *Behav Brain Res*. 2005; **158**(1): 159–166.

17. Kumari V, Das M, Taylor PJ, et al. Neural and behavioural responses to threat in men with a history of serious violence and schizophrenia or antisocial personality disorder. *Schizophr Res*. 2009; **110**(1–3): 47–58.

18. Letourneau EJ, Armstrong KS. Recidivism rates for registered and nonregistered juvenile sexual offenders. *Sexual Abuse*. 2008; **20**(4): 393–408.

19. Bastert E, Schlafke D, Pein A, Kupke F, Fegert JM. Mentally challenged patients in a forensic hospital: a feasibility study concerning the executive functions of forensic patients with organic brain disorder, learning disability, or mental retardation. *Int J Law Psychiatry*. 2012; **35**(3): 207–212.

20. Dolan M, Doyle M. Violence risk prediction: clinical and actuarial measures and the role of the Psychopathy Checklist. *Br J Psychiatry*. 2000; **177**(4): 303–311.

21. Harris GT, Rice ME. Risk appraisal and management of violent behavior. *Psychiatr Serv*. 1997; **48**(9): 1168–1176.

22. McDermott BE, Holoyda BJ. Assessment of aggression in inpatient settings. *CNS Spectr*. 2014; **19**(5): 425–431.

23. Zapf PA, Roesch R. Future directions in the restoration of competency to stand trial. *Current Directions in Psychological Science*. 2011; **20**(1): 43–47.

24. Ball EM, Young D, Dotson LA, Brothers LT, Robbins DT. Factors associated with dangerous behaviour in forensic inpatients: results from a pilot study. *Bull Am Acad Psychiatry Law*. 1994; **22**(4): 605–620.

25. Dietz PE, Rada RT. Battery incidents and batterers in a maximum security hospital. *Arch Gen Psychiatry*. 1982; **39**(1): 31–34.

26. Hillbrand M. Aggression against self and aggression against others in violent psychiatric patients. *J Consult Clin Psychol*. 1995; **63**(4): 668–671.

27. Hoptman MJ, Yates KF, Patalinjug MB, Wack RC, Convit A. Clinical prediction of assaultive behavior among male psychiatric patients at a maximum-security forensic facility. *Psychiatr Serv*. 1999; **50**(11): 1461–1466.

28. Lussier P, Verdun-Jones S, Deslauriers-Varin N, Nicholls T, Brink J. Chronic violent patients in an inpatient psychiatric hospital: prevalence, description, and identification. *Criminal Justice and Behavior*. 2009; **37**(1): 5–28.

29. Rasmussen K, Levander S. Individual rather than situational characteristics predict violence in a maximum security hospital. *J Interpers Violence*. 1996; **11**(3): 376–390.

30. Rogers P, Watt A, Gray NS, MacCulloch M, Gournay K. Content of command hallucinations predicts self-harm but not violence in a medium secure unit. *Journal of Forensic Psychiatry*. 2002; **13**(2): 251–262.

31. Thomas SD, Daffern M, Martin T, Ogloff JR, Thomson LD, Ferguson M. Factors associated with seclusion in a statewide forensic psychiatric service in Australia over a 2-year period. *Int J Ment Health Nurs*. 2009; **18**(1): 2–9.

32. Foster HG, Hillbrand M, Silverstein M. Neuropsychological deficit and aggressive behaviour: a prospective study. *Prog Neuropsychopharmacol Biol Psychiatry*. 1993; **17**(6): 939–946.

33. Yudofsky SC, Silver JM, Jackson W, Endicott J, Williams D. The overt aggression scale for the objective rating of verbal and physical aggression. *Am J Psychiatry*. 1986; **143**(1): 35–39.

34. Benton AL, Varney NR, Hamsher KS. Visuospatial judgment: a clinical test. *Arch Neurol*. 1978; **35**(6): 364–367.

35. Stroop JR. Studies of interference in serial verbal reactions. *J Exp Psychol*. 1935; **18**(6): 643–662.

36. Enticott PG, Ogloff JR, Bradshaw JL, Daffern M. Contrary to popular belief, a lack of behavioural inhibitory control may not be associated with aggression. *Crim Behav Ment Health*. 2007; **17**(3): 179–183.

37. Enticott PG, Ogloff JRP, Bradshaw JL. Associations between laboratory measures of executive inhibitory control and self-reported impulsivity. *Personality and Individual Differences*. 2006; **41**(2): 285–294.

38. Murphy D. Theory of mind functioning in mentally disordered offenders detained in high security psychiatric care: its relationship to clinical outcome, need and risk. *Crim Behav Ment Health*. 2007; **17**(5): 300–311.

39. Wechsler D. *Wechsler Adult Intelligence Scale*, 3rd ed. San Antonio, TX: Harcourt Assessment; 1997.

40. Reitan RM, Wolfson D. Category test and trail making test as measures of frontal lobe functions. *Clinical Neuropsychologist*. 1995; **9**(1): 50–56.

41. Baron-Cohen S, Wheelwright S, Hill J, Raste Y, Plumb I. The "Reading the Mind in the Eyes" Test Revised Version: a study with normal adults, and adults with Asperger syndrome or high-functioning autism. *J Child Psychol Psychiatry*. 2001; **42**(2): 241–251.

42. Frith CD, Corcoran R. Exploring 'theory of mind' in people with schizophrenia. *Psychol Med*. 1996; **26**(3): 521–530.

43. Blair RJ. A cognitive developmental approach to mortality: investigating the psychopath. *Cognition*. 1995; **57**(1): 1–29.

44. Mathersul D, McDonald S, Rushby JA. Understanding advanced theory of mind and empathy in high-functioning adults with autism spectrum disorder. *J Clin Exp Neuropsychol*. 2013; **35**(6): 655–668.

45. Roncone R, Falloon IRH, Mazza M, et al. Is theory of mind in schizophrenia more strongly associated with clinical and social functioning than with neurocognitive deficits? *Psychopathology*. 2002; **35**(5): 280–288.

46. Hillbrand M, Spitz RT, Foster HG. Serum cholesterol and aggression in hospitalized male forensic patients. *J Behav Med*. 1995; **18**(1): 33–43.

47. Hillbrand M, Spitz RT, Foster HG, Krystal JH, Young JL. Creatine kinase elevations and aggressive behavior in hospitalized forensic patients. *Psychiatr Q*. 1998; **69**(1): 69–82.

48. Repo-Tiihonen E, Paavola P, Halonen P, Tiihonen J. Seclusion treatment measures and serum cholesterol levels among Finnish male forensic psychiatric patients. *Journal of Forensic Psychiatry*. 2002; **13**(1): 157–165.

49. Spitz RT, Hillbrand M, Foster HG, Svetina CJ. Ethnicity, aggression and serum creatine kinase in hospitalized male forensic patients. *Ethn Dis*. 1997; **7**(3): 259–270.

50. Wallimann T, Wyss M, Brdiczka D, Nicolay K, Eppenberger HM. Intracellular compartmentation, structure and function of creatine

kinase isoenzymes in tissues with high and fluctuating energy demands: the 'phosphocreatine circuit' for cellular energy homeostas. *Biochem J*. 1992; **281**(1): 21–40.

51. Baldwin LJ, Menditto AA, Beck NC, Smith SM. Factors influencing length of hospitalization for NGRI acquittees in a maximum security facility. *Journal of Psychiatry & Law*. 1992; **20**(2): 257–267.

52. Edwards J, Steed P, Murray K. Clinical and forensic outcome 2 years and 5 years after admission to a medium secure unit. *Journal of Forensic Psychiatry*. 2002; **13**(1): 68–87.

53. Long CG, Dolley O. Factors predictive of length of stay for women in medium secure settings. *J Psychiatr Ment Health Nurs*. 2012; **19**(10): 870–874.

54. Rice ME, Quinsey VL, Houghton R. Predicting treatment outcome and recidivism among patients in a maximum security token economy. *Behav Sci Law*. 1990; **8**(3): 313–326.

55. Skipworth J, Brinded P, Chaplow D, Frampton C. Insanity acquittee outcomes in New Zealand. *Aust N Z J Psychiatry*. 2006; **40**(11–12): 1003–1009.

56. Steadman HJ, Pasewark RA, Hawkins M, Kiser M, Bieber S. Hospitalization length of insanity acquittees. *J Clin Psychol*. 1983; **39**(4): 611–614.

57. Green B, Baglioni AJ. Length of stay, leave and reoffending by patients from a Queensland security patients hospital. *Aust N Z J Psychiatry*. 1998; **32**(6): 839–847.

58. Andreasson H, Nyman M, Krona H, *et al*. Predictors of length of stay in forensic psychiatry: the influence of perceived risk of violence. *Int J Law Psychiatry*. 2014; **37**(6): 635–642.

59. Moran MJ, Fragala R, Wise BF, Novak TL. Factors affecting length of stay on maximum security in a forensic psychiatric hospital. *International Journal of Offender Therapy and Comparative Criminology*. 1999; **43**(3): 262–274.

60. Brown K, Fahy T. Medium secure units: pathways of care and time to discharge over a four-year period in South London. *Journal of Forensic Psychiatry & Psychology*. 2009; **20**(2): 268–277.

61. Castro M, Cockerton T, Birke S. From discharge to follow-up: a small scale study of medium secure provision in the independent sector. *British Journal of Forensic Practice*. 2002; **4**(3): 31–39.

62. Baxter R, Rabe-Hesketh S, Parrott J. Characteristics, needs and reoffending in a group of patients with schizophrenia formerly treated in medium security. *Journal of Forensic Psychiatry*. 1999; **10**(1): 69–83.

63. Buchanan A. Criminal conviction after discharge from special (high security) hospital: incidence in the first 10 years. *Br J Psychiatry*. 1998; **172**(6): 472–476.

64. Buchanan A, Leese M. Quantifying the contributions of three types of information to the prediction of criminal conviction using the receiver operating characteristic. *Br J Psychiatry*. 2006; **188**(5): 472–478.

65. Cohen MI, Spodak MK, Silver SB, Williams K. Predicting outcome of insanity acquittees released to the community. *Behav Sci Law*. 1988; **6**(4): 515–530.

66. Friendship C, McClintock T, Rutter S, Maden A. Re-offending: patients discharged from a regional secure unit. *Crim Behav Ment Health*. 1999; **9**(3): 226–236.

67. Maden A, Rutter S, McClintock T, Friendship C, Gunn J. Outcome of admission to a medium secure psychiatric unit. I. Short- and long-term outcome. *Br J Psychiatry*. 1999; **175**(4): 313–316.

68. Philipse MW, Koeter MW, van der Staak CP, van den Brink W. Static and dynamic patient characteristics as predictors of criminal recidivism: a prospective study in a Dutch forensic psychiatric sample. *Law Hum Behav*. 2006; **30**(3): 309–327.

69. Phillips HK, Gray NS, MacCulloch SI, *et al*. Risk assessment in offenders with mental disorders: relative efficacy of personal demographic, criminal history, and clinical variables. *J Interpers Violence*. 2005; **20**(7): 833–847.

70. Quinsey VL, Rice ME, Harris GT. Actuarial prediction of sexual recidivism. *J Interpers Violence*. 1995; **10**(1): 85–105.

71. Rice ME, Harris GT. Predicting the recidivism of mentally disordered firesetters. *J Interpers Violence*. 1996; **11**(3): 364–375.

72. Rice ME, Harris GT, Lang C, Bell V. Recidivism among male insanity acquittees. *Journal of Psychiatry & Law*. 1990; **18**(3–4): 379–403.

73. Duncan JM, Short A, Lewis JSG, Barrett PT. Re-admissions to the State Hospital at Carstairs, 1992–1997. *Health Bull (Edinb)*. 2002; **60**(1): 70–82.

74. Tennent G, Way C. The English Special Hospital–a 12-17 year follow-up study: a comparison of violent and non-violent re-offenders and non-offenders. *Med Sci Law*. 1984; **24**(2): 81–91.

75. Quinsey VL, Maguire A. Maximum security psychiatric patients: actuarial and clinical prediction of dangerousness. *J Interpers Violence*. 1986; **1**(2): 143–171.

76. Zonana HV, Bartel RL, Wells JA, Buchanan JA, Getz MA. Part II: sex differences in persons found not guilty by reason of insanity: analysis of data from the Connecticut NGRI Registry. *Bull Am Acad Psychiatry Law*. 1990; **18**(2): 129–151.

77. Rice ME, Harris GT, Quinsey VL. A follow-up of rapists assessed in a maximum-security psychiatric facility. *J Interpers Violence*. 1990; **5**(4): 435–448.

78. Maden A, Friendship C, McClintock T, Rutter S. Outcome of admission to a medium secure psychiatric unit. 2. Role of ethnic origin. *Br J Psychiatry*. 1999; **175**(4): 317–321.

79. Reiss D, Grubin D, Meux C. Young 'psychopaths' in special hospital: treatment and outcome. *Br J Psychiatry*. 1996; **168**(1): 99–104.

80. Howard R, McCarthy L, Huband N, Duggan C. Re-offending in forensic patients released from secure care: the role of antisocial/borderline personality disorder co-morbidity, substance dependence and severe childhood conduct disorder. *Crim Behav Ment Health*. 2013; **23**(3): 191–202.

81. Bailey J, Macculloch M. Patterns of reconviction in patients discharged directly to the community from a special hospital: implications for aftercare. *Journal of Forensic Psychiatry*. 1992; **3**(3): 445–461.

82. Quinn P, Ward M. What happens to special hospital patients admitted to medium security? *Med Sci Law*. 2000; **40**(4): 345–349.

83. Howard R, Lumsden J. A neurophysiological predictor of reoffending in special hospital patients. *Crim Behav Ment Health*. 1996; **6**(2): 147–156.

84. Howard RC, Fenton GW, Fenwick PBC. The contingent negative variation, personality and antisocial behaviour. *Br J Psychiatry*. 1984; **144**(5): 463–474.

85. Howard RC. Brain waves, dangerousness and deviant desires. *Journal of Forensic Psychiatry*. 2002; **13**(2): 367–384.

86. Harris ST, Oakley C, Picchioni M. Quantifying violence in mental health research. *Aggression and Violent Behavior*. 2013; **18**(6): 695–701.

87. Bechara A, Damasio AR, Damasio H, Anderson SW. Insensitivity to future consequences following damage to human prefrontal cortex. *Cognition*. 1994; **50**(1): 7–15.

88. Bass SLS, Nussbaum D. Decision making and aggression in forensic psychiatric inpatients. *Criminal Justice and Behavior*. 2010; **37**(4): 365–383.

89. Fullam R, Dolan MC. Executive function and in-patient violence in forensic patients with schizophrenia. *Br J Psychiatry*. 2008; **193**(3): 247–253.

90. Nelson HE, Willison JR. *The revised national adult reading test - Test manual*. Windsor, UK: NFER-Nelson.

91. Wechsler D. *The Wechsler Abbreviated Scale of Intelligence*. New York: The Psychological Corporation: Harcourt Brace & Company; 1999.

92. Rubia K, Russell T, Overmeyer S, *et al*. Mapping motor inhibition: conjunctive brain activations across different versions of go/no-go and stop tasks. *Neuroimage*. 2001; **13**(2): 250–261.

93. Fray PJ, Robbins TW. CANTAB battery: proposed utility in neurotoxicology. *Neurotoxicol Teratol*. 1996; **18**(4): 499–504.

94. Golomb BA, Stattin H, Mednick S. Low cholesterol and violent crime. *J Psychiatr Res*. 2000; **34**(4–5): 301–309.

95. Kaplan JR. Assessing the observed relationship between low cholesterol and violence-related mortality: implications for suicide risk. *Ann N Y Acad Sci*. 1997; **836**: 57–80.

96. Roaldset JO, Bakken AM, Bjørkly S. A prospective study of lipids and serotonin as risk markers of violence and self-harm in acute psychiatric patients. *Psychiat Res*. 2011; **186**(2–3): 293–299.

97. Virkkunen M, Rissanen A, Franssila-Kallunki A, Tiihonen J. Low non-oxidative glucose metabolism and violent offending: an 8-year prospective follow-up study. *Psychiatr Res*. 2009; **168**(1): 26–31.

98. Stalenheim EG. Long-term validity of biological markers of psychopathy and criminal recidivism: follow-up 6-8 years after forensic psychiatric investigation. *Psychiatr Res*. 2004; **121**(3): 281–291.

99. Singh I, Rose N. Biomarkers in psychiatry. *Nature*. 2009; **460** (7252): 202–207.