Risk assessment of imminent violence in acute psychiatry: A step towards an extended model

**Short running title:** Towards an extended model for short-term risk assessment

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**AUTHOR CONTRIBUTIONS**

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**ETHICAL STATEMENTS**

The application was processed and the research approved by the Regional Committee for Medical and Health Research Ethics (REK Sør-Øst B) in Norway on 11 January 2012 (Protocol reference: 2011/2555/REK sør-øst B). The approval granted exemption from requesting patients' informed consent to participate but required all patients to be informed

about their participation and right to withdraw. The project was also approved by the Privacy Department of Oslo University Hospital (E-phorte No. 2011/22191).

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## Abstract

Aggression occurs frequently in mental health care settings, and studies have reported that 17% to 31% of patients admitted to acute psychiatric wards commit violence. Inpatients' fluctuating mental states and behaviour patterns reinforce the need for an assessment instrument to predict potential violence in a timely manner. This naturalistic prospective inpatient study investigated whether an extended short-term risk assessment model that combines (a) short-term risk assessment with the Broset Violence Checklist (BVC), (b) patient's own prediction of violence with the Self-Report Risk Scale (SRS) and (c) single items from the Violence Risk Screening 10 (V-RISK-10) provides better short-term predictive accuracy for violence than the BVC alone. All patients admitted to a psychiatric emergency hospital in Norway during one year were included ($N$ = 508). Stepwise multivariate generalised linear mixed model analyses were conducted. When adjusting for repeated measurements, the results indicated that an extended model for short-term risk assessment, consisting of the BVC, SRS and Item 2 *Previous and/or current threats* from the V-RISK-10 explained more variance of imminent violence, compared to the BVC alone. Further studies are recommended to investigate whether the extended model provides a clinically better short-term risk prediction of imminent violence, compared to the BVC alone.



## KEYWORDS

acute psychiatry; aggression; repeated measurements; risk assessment; violence

## Introduction

Violence in the health sector is a global and increasing concern (Gates, 2004; Kuehn, 2010; Llor-Esteban, Sánchez-Muñoz, Ruiz-Hernández, & Jiménez-Barbero, 2016). Aggression occurs frequently in mental health care settings and is perpetrated by both males and females (Cutcliffe & Riahi, 2013; Duxbury, Hahn, Needham, & Pulsford, 2008). Acute psychiatric hospital environments are associated with a higher risk of inpatient violence (Abderhalden et al., 2007), and studies have reported that 17% to 31% of patients admitted to acute psychiatric wards commit violence (Bowers et al., 2011; Iozzino, Ferrari, Large, Nielssen, & de Girolamo, 2015). In acute psychiatric settings, clinicians are forced to make decisions quickly and may have less clinical and behavioural information available on admission than clinicians in long-term clinical settings (Anderson & Jenson, 2018). Fluctuating mental states and behaviour patterns in the acute psychiatric setting reinforce the need for an assessment instrument to predict the potential for aggressive and violent events in a timely manner (Abderhalden et al., 2004; Almvik, Woods, & Rasmussen, 2000; Bjorkdahl, Olsson, & Palmstierna, 2006), and thus risk assessment for imminent violence has been promoted as one strategy to prevent violence. Short-term risk assessment is premised on the identification of early warning signs, so that necessary action can be taken to prevent aggressive and violent behaviour (Abderhalden et al., 2008; Maguire, Daffern, Bowe, & McKenna, 2017). The Broset Violence Checklist (BVC) is such short-term risk instrument for prediction of violence the next 24 hours (Almvik et al., 2000). The BVC shows good inter-rater reliability, sensitivity, and specificity (Almvik et al., 2000; Hvidhjelm, Sestoft, Skovgaard, & Bue Bjorner, 2014). The reported predictive validity, as measured by area under the receiver operating characteristic curve (ROC-AUC) (Abderhalden et al., 2006; van de Sande et al., 2011) for BVC were found to be comparable with instruments developed for more comprehensive risk assessment (Bjørkly, Hartvig, Roaldset, & Singh, 2014).

Several studies have shown an association between a consistent procedure of measuring behaviour with the BVC and a reduction in violence (Abderhalden et al., 2006; Abderhalden et al., 2008; van de Sande et al., 2011; van de Sande et al., 2013). A more recent Danish quasi experimental study, which included 15 psychiatric wards, did not find any significant reduction in risk of violence after implementing the BVC, and additional intervention studies with more statistical power are needed to reach final conclusions (Hvidhjelm et al., 2016). Previous studies on risk assessment of imminent violence have been limited in at least three aspects: the examination of only one instrument at the time, use of professionals' observations without including patients' self-perceptions of risk, and use of statistical and methodological analysis which do not adjust for repeated measurements. However, a recent study on imminent aggression in female forensic inpatients which assessed the predictive validity of the Dynamic Appraisal of Situational Aggression: Woman's Version adjusted for repeated measures by using a two stage modelling approach. In the first stage a two-level hierarchical (multilevel) model was fitted to estimate the probability of aggression outcomes. The second stage used the estimated probability as the predictor of aggression outcomes in a logistic regression, and the results were then used to produce a ROC curve (Riordan et al., 2019).

The V-RISK 10 and BVC are both recommended by the Norwegian Directorate of Health as instruments for screening or initial mapping of risk (Norwegian Directorate of Health, 2018) in acute psychiatric inpatient units. A more recent literature review which examined violence risk assessment screening tools also found that the BVC and the Violence Risk Screening 10 (V-RISK-10) were the two instruments that provided enough statistical information to be considered for use in acute psychiatric settings (Anderson & Jenson, 2018). V-RISK-10 is designed to be used for screening at admittance and the BVC, to be used at each nursing shift. To our knowledge, there are no previous studies that combine the two

instruments. Most structured violence risk assessment instruments achieve a moderate accuracy, suggesting a 'glass ceiling' effect (Coid et al., 2011; Yang, Wong, & Coid, 2010), which may be a result of efficient violence risk management based on the prior identifyed high risk. Thus, there is a need to investigate whether different and extended approaches may improve predictions (Singh, Serper, Reinharth, & Fazel, 2011). One review also highlighted the importance of multiple approaches (Steinert & Whittington, 2013), pointing out that different perspectives may provide improved knowledge about risk assessment. An extended use of sources of predictive information for violence risk assessments, through the physicians' assessments at admission, the nurses' assessments at each nursing shift, and the patients' own prediction of violence at admission, may represent such use of multiple approaches.

Though self-report scales are included in comprehensive instruments used for risk assessments in psychiatry (Fluttert, van Meijel, Nijman, Bjorkly, & Grypdonck, 2010; Gardner, Boccaccini, Bitting, & Edens, 2015; Loza, Loza-Fanous, & Heseltine, 2007), patients' subjective violence risk assessment has rarely been emphasised as useful in violence risk assessment, and only a few studies have addressed the topic (Lockertsen et al., 2017; Roaldset & Bjorkly, 2010; Skeem, Manchak, Lidz, & Mulvey, 2013). Two of these studies examined the Self-report Risk Scale (SRS), of which both studies found predicted inpatient violence (Lockertsen et al., 2017; Roaldset & Bjorkly, 2010). The SRS was also included in a bio-psycho social model of violence risk assessment in acute psychiatry (Eriksen, Faerden, Lockertsen, Bjorkly, & Roaldset, 2018), but was found to be insignificant for the inpatient setting. As far as we know, to date no studies include patients' self-perceptions of risk in short-term risk assessment models.

Receiver Operating Characteristics (ROC) analysis, and its resultant area under the curve (AUC), is a popular method by which to evaluate an instrument's predictive value (Zou, O'Malley, & Mauri, 2007), and previous statistical analysis has mainly been limited to ROC

analysis (Abderhalden et al., 2004; Almvik et al., 2000; Chu, Thomas, Daffern, & Ogloff, 2013; Hvidhjelm, Sestoft, Skovgaard, et al., 2014; Maguire et al., 2017; Rechenmacher, Muller, Abderhalden, & Schulc, 2014; Vojt, Marshall, & Thomson, 2010) or ROC analysis combined with logistic regression (Chu, Daffern, & Ogloff, 2013; Hvidhjelm, Sestoft, & Bjorner, 2014). However, in ROC analysis and logistic regression, all assessments are included and treated as independent observations, not adjusting for repeated measurements or measurement dependency. This gives rise to a potential bias risk (Coid, Kallis, Doyle, Shaw, & Ullrich, 2015; Maguire et al., 2017) and caution regarding erroneous conclusions about predictive accuracy. Few studies, mainly from forensic psychiatry, adjust for repeated measurements either by using generalised estimating equations (GEE) (Maguire et al., 2017; Nqwaku et al., 2018) or by accounting for the correlation in the logistic regressions with a compound symmetry structure for the working correlation matrix (by QIC statistic) (Hvidhjelm, Sestoft, Skovgaard, et al., 2014). One study from acute psychiatric intensive care calculated a daily highest BVC sum score, then used survival analysis with an extended Cox Model (Bjorkdahl et al., 2006). In another study from the current risk assessment research project (Lockertsen, Varvin, Faerden &Vatnar, 2019), we adjusted for multiple assessments and episodes by the same patient by using generalised linear mixed model (GLMM) analysis.

***Aim***

This study examines risk assessment of imminent violence by investigating whether an extended short-term risk assessment model combining (i) short-term risk assessment with the BVC, (ii) patients' own prediction of violence with the SRS and (iii) single items from V-RISK-10 would provide improved short-term predictive accuracy of violence compared to the BVC alone.

## Method

### *Design, setting and participants*

This study was part of a naturalistic prospective in-patient risk assessment research project conducted at an acute psychiatric ward in Oslo (Norway). The ward had five units, with a total of 45 beds for all emergency mental health admissions and served a catchment area of about 204 000 individuals older than 18 years. The research project was approved by the Regional Committee for Medical and Health Research Ethics in Norway (2011/2555/REK sør-øst B). The ethics approval granted an exemption from asking for patients' informed consent to participate, but required all patients to be informed verbally and in writing about both the study and their right to withdraw from participating.

The research project included all involuntarily and voluntarily patients admitted during one calendar year (March 2012 to March 2013) and initially consisted of 558 patients with 755 admissions and 415 recorded violent episodes with the SOAS-R. This initial sample overlapped with previous studies that investigated different selections of baseline and/or outcome variables. Because of missing records in different variables, there were different selections of patients and admissions in the final samples of the respective studies (Eriksen, Bjorkly, Lockertsen, Faerden, & Roaldset, 2017; Eriksen et al., 2016; Eriksen et al., 2018; Lockertsen et al., 2017; Lockertsen et al., 2019).

In the current study patients with missing of either V-RISK 10 or SRS were excluded. Missing risk assessments with the BVC (in total 2014 recordings) were categorized as, ordinary leave (1597), absence without leave (149), treatment at somatic hospital ward (97), or other missing (171), and not included in the analyses.

In total, 30 patients out of the initial sample chose to withdraw from participation. One admission was chosen for each patient; for patients with more than one admission, the first admission with recorded BVC, V-RISK 10, SRS and violence was chosen. For non-violent

patients, the first admission with recorded BVC, V-RISK 10 and SRS was used. Twenty patients (with 45 recorded episodes of violence) out of the remaining 528 were excluded due to missing V-RISK 10 or SRS. For patients with more than one episode of violence during one nursing shift, the most severe form of violence was coded. If a patient had a violent episode, imminent recordings of BVC (234 recordings) were excluded because the violent episode would bias the imminent BVC score.

After exclusions due to missing recordings of the BVC, SRS, and V-RISK-10, duplicated recordings of violence incidents, multiple episodes of violence during nursing shifts, and incomplete recording of violent incidents, the final study sample consisted of $N$ = 508 patients and 234 episodes of violence.

Insert Table 1 approximately here

***Procedure***

Written information about the study was provided to each patient after admission and before discharge. The physician on duty recorded V-RISK 10, in accordance with the recommendation by the Norwegian Directorate of Health (2018), and SRS as part of the admission procedure. All physicians employed at the acute psychiatric ward received standard employment training which included conducting risk assessments both with SRS and V-RISK 10. Clinical and demographic variables included gender, age, marital status, education, length of the hospitalisation, voluntary or involuntary admission and ICD 10 diagnoses were retrieved from hospital records by the researchers. All the nursing staff were familiar with the recommended BVC (Norwegian Directorate of Health, 2018) beforehand, because the BVC was implemented as standard practice four years ahead of the study and all the nursing staff receive standard employment training including conducting risk assessments with the BVC.

The BVC was completed for all inpatients for all nursing shifts during each inpatient's entire hospital stay. Unlike what the BVC recommends (Almvik et al., 2000), each patient's primary nurse completed the BVC at *the end* of each nursing shift instead of *at the beginning* as recommended. The main implication of the different procedure is that the staff who records violent episodes no longer may be the same staff that complete the respective BVC score. Hence some of the interpersonal factors affecting the risk of violence and the BVC scores changes from when the assessments are made until the episodes of violence occur. This data collection procedure aligned with existing ward practice and previous studies of BVC use (Abderhalden et al., 2006; Abderhalden et al., 2008; Abderhalden et al., 2004; Chu et al., 2013).

In line with the two previous randomised controlled trial (RCT) studies on the BVC (Abderhalden et al., 2008; van de Sande et al., 2011), all violent episodes during the hospital stay were recorded by the nursing staff, using the Staff Observation Aggression Scale-Revised (SOAS-R) (Nijman et al., 1999). Because the SOAS-R had already been used on the wards for a year as part of another research project, nursing staff taking part in data collection were experienced in the use of this form. To compensate for possible underreporting, researchers recorded additional episodes of violence in the SOAS-R retrieved from restraint forms and the daily staff reports. According to the Norwegian Mental Health Care Act, the use of restraints has to be recorded. The following types of restraints can be utilized; mechanical restraints, seclusion, pharmacological restraints, and physical holding (refers to a technique where members of staff restrain a patient physically without any aids). The daily staff report is a short report about each patient during each nursing shift, which is written by a (mental health) nurse to facilitate transference of information between shifts. In total 87 additional episodes of violence (37.2 % out of all episodes) were retrieved from the restraint forms and the daily staff reports.

***Baseline variables***

The BVC, which was developed from the empirical work of Linaker and Busch-Iversen (1995), consists of the following six most frequent behavioural changes recorded during a 24-hour period prior to a violent incident occurring: confusion, irritability, boisterousness, physical threats, verbal threats and attacks on objects. It is scored for the presence (= 1) or absence (= 0) of these six behaviours (Almvik & Woods, 2003; Almvik et al., 2000). When assessments with BVC are conducted at the end of each nursing shift and the outcome interval is set to the imminent nursing shift, the following interpretation is suggested; BVC sum score of 0 = low risk; 1 – 3 = moderate risk; ≥ 4 = high risk (Lockertsen et al., 2019). Thus the BVC was transformed into an ordinal variable (BVC-ordinal) in accordance with these suggestions. A number of studies, including two RCT studies (Abderhalden et al., 2008; van de Sande et al., 2011), show good predictive validity for the BVC also when it is used during an entire hospitalisation and adjusted for repeated measurements (Lockertsen et al., 2019).

The patients were asked to state their opinions about the risk that they would threaten or act violently towards others during hospitalisation. A modified version of the original SRS (Roaldset & Bjorkly, 2010) was used. The patients were asked to choose one of six response options that they felt best explained their self-assessment of risk of violence during hospitalisation: no risk (will definitely not happen), low risk (is unlikely to happen), moderate risk (limited to certain situations), high risk (will happen in many situations), don't know, and won't answer. The 'don't know' and 'won't answer' categories had been previously reported as indicating increased risk of violence (Lockertsen et al., 2017; Roaldset & Bjorkly, 2010). To increase power and decrease the risk of Type II errors, the SRS was transformed to a dichotomous variable (SRS-d). The two previous studies on SRS used different cut-offs; either 'no risk' as reference and all other categories as risk (Roaldset & Bjorkly, 2010) or 'no

risk' and 'low risk' as reference (Lockertsen et al., 2017). Based on experiences from clinical everyday life in acute settings the "risk distinction" will rather be between low and moderate risk than between no, and low risk. Then, SRS was dichotomised with 'no' and 'low' as the reference category and the other response options as the risk category.

The V-RISK-10 is a screening tool for violence risk developed for acute and general psychiatry and consists of 10 items (Eriksen et al., 2016; Hartvig, Roaldset, Moger, Ostberg, & Bjorkly, 2011; Roaldset, Hartvig, & Bjorkly, 2011). Each item was recorded as no, maybe/moderate, and yes. As in previous studies (Eriksen et al., 2016; Hartvig, Roaldset, Moger, Ostberg, et al., 2011; Roaldset et al., 2011), 'don't know' scores showed a predictive power similar to maybe/moderate, so these groups were combined for analyses.

***Outcome variables***

The main outcome measure was *imminent violence*; the occurrence of violent behaviour during the next nursing shift (0800-1530 hr, 1530-2230 hr, 2230-0800 hr) following assessment. *Violence* was defined and measured in accordance with previous studies (e.g. Monahan et al., 2005). *Physical violence* was measured as a physical act against another person, involving the use of body parts or objects, with a clear intention (as it was perceived and interpreted by the person who was the target of the physical act) to cause physical injury to that person. *Threats* were measured as verbal and non-verbal communications conveying a clear intention to inflict physical injury upon another person (Dean et al., 2006; Eriksen et al., 2016; Lockertsen et al., 2017; Monahan et al., 2005; Roaldset et al., 2011). The SOAS-R was used to record violence to others (Nijman et al., 1999). Recording of violence was limited to physical violence and verbal threats as defined above.

The secondary outcome measure was *any violent behaviour during hospitalisation*. This secondary outcome was used in the preliminary analyses when scrutinising the

association of patient characteristics, SRS, and single items of the V-RISK-10 with violent behaviour.

### *Statistical analysis*

The Risk Assessment Guidelines for the Evaluation of Efficacy (RAGEE guidelines) (Singh, Yang, & Mulvey, 2015) were used to report results for the present study. Data were analysed using IBM SPSS Statistics for Windows, Version 24.0, and Stata Statistical Software: Release 15.

Episodes of threats and physical acts were recoded into a dichotomous variable (no violence vs. any violence) in order to achieve a larger number of outcome episodes and to increase statistical power. Initially the Mann–Whitney U-test and the students t-test were conducted to test differences on continuous variables between groups and subsamples. Chi-square tests were used to analyse categorical variables.

GLMM is useful when the data are clustered (Rabe-Hesketh & Skrondal, 2010). GLMM is also more robust to the presence of missing data, including different numbers of assessments due to different lengths of hospital stay, compared to GEE (Gibbons, Hedeker & DuToit, 2010). GLMM analyses were conducted to determine whether the BVC ordinal predicts violence when the observations are correlated. Data analyses were conducted in four stages.

Stage 1 consisted of a GLMM analysis of the BVC assessments (Table 2). Intra-class coefficients (ICC) and variance between patients were estimated for the respective analyses. The odds ratios (ORs) determined the likelihood that the patients would be violent, depending on their BVC-ordinal scores.

In stage 2, univariate logistic regression analysis was conducted to estimate the association between patient characteristics (Table 4), between patients' self-perception of risk

by SRS-d, and between single items in V-RISK-10 (Table 3) and violent behaviour during the hospitalisation.

In stage 3, two separate stepwise backwards multivariate logistic regression analyses were conducted: One analysis in which all patient characteristics significant in the univariate analysis were included, and another wherein all V-RISK-10 single items significant in the univariate analysis were included.

In stage 4, stepwise multivariate GLMM analyses were conducted in order to build an extended model of the BVC. The extended model consisted of three steps: (i) BVC-ordinal alone, (ii) BVC-ordinal and SRS-d and (iii) the final extended model in which BVC-ordinal, SRS-d and Item 2 *Previous and/or current threats* from V-RISK-10 were included. The extended model was adjusted for all patient characteristics significant in the multivariate logistic regression analyses conducted in stage 3 (Table 4). ICC and variance between patients were estimated.

Akaike's information criterion (AIC) and Bayesian information criterion (BIC) were used as fit indices to estimate the quality of the models. AIC and BIC estimate the quality of each model, relative to each of the other candidate models. AIC estimates the relative information lost by a given model: The less information a model loses, the higher the quality of that model (Burnham & Anderson, 2002). The BIC will select the true model if, among other assumptions, the true model is among the models considered. The AIC is efficient when the true model is not in the candidate model set because it will asymptotically choose whichever model minimises the mean squared error of prediction (Vrieze, 2012).

All analyses were conducted for both SRS, with *don't know* and *won't answer* treated as missing, and SRS-d. GLMM analyses were conducted for the BVC as a categorical variable from 0-6 and BVC-ordinal (Table 2).

In order to compare the results with previous studies, AUC of ROC analysis was calculated to determine overall predictive accuracy for the BVC treated as independent measures. GLMM decreases the marginal distribution of violent episodes, thus provides significant influence upon sensitivity, specificity, positive predictive value, negative predictive value, number needed to access, and likelihood ratio. Accordingly, the respective results would be incomparable with previous results, and were therefore, in spite of the recommendations in Singh et al. (2015), not included in the study.

## Results

### *Descriptive data and proportions of violence*

Table 1 shows the distribution of patient characteristics divided between violent and nonviolent patients. Length of patient hospitalisation ranged from less than one nursing shift (8 hours) to 175 days, and the number of risk assessments with the BVC per patient ranged from 1 to 505, with a mean of 46. Seventy-three patients (14.4%) displayed violent behaviour during hospitalisation. In all, 188 (80.3%) out of the 234 registered violent episodes were characterised as physical violence, while the remaining 46 consisted of verbal threats only.

Insert Table 2 approximately here

### *BVC adjusted for repeated measurements*

When adjusted for repeated measurements, BVC sum score was significantly associated with imminent violence (see Table 2). The GLMM analyses found the BVC-ordinal significantly associated with violence. The ICC for the BVC-ordinal was 0.38 (95% CI = 0.28-0.51) and variance between patients = 1.43 (95% CI = 1.12-1.84).

### *SRS-d and Item 2 Previous and/or current threats from V-RISK-10*

Univariate logistic regression analyses found the SRS-d significantly associated with violent behaviour during hospitalisation (OR = 3.92, 95% CI = 2.30-6.66, $p < 0.001$). For this reason, the SRS-d was included in the construction of an extended model for short-term risk assessment.

Table 3 shows the association between single items in V-RISK-10 and violent behaviour during hospitalisation with both univariate and multivariate logistic regression. Item 2 *Previous and/or current threats* had the highest predictive value in the univariate logistic regression. In the multivariate analysis, Item 2 *Previous and/or current threats* and Item 7 *Expresses suspicion* remained significant; hence the respective items were included in the construction of an extended model for short-term risk assessment.

Insert Table 3 approximately here

### *The combination of instruments: BVC-ordinal, SRS-d and Item 2 from V-RISK-10*

The BVC-ordinal, SRS-d, and Item 2 *Previous and/or current threats* from V-RISK-10 remained significant in the stepwise development of an extended model for short-term risk assessment. The final extended model is displayed as Step 3 in Table 5. The AIC and BIC decreased both when adding SRS-d (Step 2) and when adding Item 2 from V-RISK-10 *Previous and/or current threats* (Step 3) in the development of the extended model for short-term risk assessment. For the extended model, the ICC was 0.34 (95% CI = 0.24-0.47), and the variance between patients was 1.31 (95% CI = 1.01-1.70).

All components of the final extended model (BVC-ordinal, SRS-d and Item 2 from V-RISK-10) remained significantly associated with imminent violence when controlled for gender.

Insert Table 4 approximately here

### *Results compared to recommended analysis*

When all BVC assessments were treated as independent measures, the ROC-AUC for BVC was 0.78 (95% CI = 0.75-0.81, $p < 0.001$). GLMM analyses are more advanced compared to the recommended analyses according to RAGEE (Singh et al., 2015). When using GLMM to adjust for repeated measurements, the marginal distribution for violent incidents decreased (from 0.95 % to 0.17 %).

## Discussion

### *Main findings*

We found evidence to support the predictive accuracy of an extended short-term risk assessment model, consisting of the BVC, patients' own prediction of violence with the SRS, and Item 2 *Previous and/or current threats* in V-RISK-10. The extended model explained more of the imminent violence throughout the hospitalisation, compared to short-term risk assessments with the BVC alone. The BVC-ordinal, SRS-d and Item 2 in V-RISK-10 all remained significant components of the model, when controlling for gender.

### *Short-term risk assessments with BVC adjusted for repeated measurements*

Managing violence risk through early identification of risk factors and appropriate, timely interventions optimises the potential for safer outcomes for patients and healthcare staff (Sands, Elsom, Gerdtz, & Khaw, 2012). BVC are already proven to show satisfactory accuracy as to the short-term prediction of violence amongst newly admitted patients in acute psychiatric units (Abderhalden et al., 2004). This study takes into account the repeated nature

of the observations; thus the current results have decreased the risk of erroneous conclusions and risk of bias, compared to previous studies using ROC-AUC and logistic regression.

### *Different perspectives on risk assessments*

The BVC is normally assessed by the nursing staff (Almvik et al., 2000), while the V-RISK-10 is typically administered at admission by the physician on duty (Eriksen et al., 2016; Hartvig, Roaldset, Moger, Østberg, & Bjørkly, 2011), and the SRS is assessed by the patients. These three instruments represent three different perspectives on violence risk assessments: the nursing staffs', the physicians', and the patients' subjective perspectives. The nursing staffs' approach represented by the BVC might be influenced by the relatively close observations brought about by proximity to the patients, whereas later, in the hospital stay, a closer relationship might also contribute to more open and honest behaviour. The physicians' approach represented by the V-RISK-10 assessed at admission might be more objective, since the physician would have to rely on written documentation (where this applies) and information gathered in an often first-time meeting. The patients' self-perception may reveal information not visible to others. It is also possible that patients themselves may have more positive experiences because they feel more empowered by being included in the violence risk assessment.

Insert Table 5 approximately here

### *A step towards an extended model - BVC, SRS and Item 2 from V-RISK-10*

Both the BVC and the V-RISK-10 are recommended for acute psychiatric settings (Anderson & Jenson, 2018) for screening at admission (V-RISK-10) and for short-term risk assessment of imminent violence (BVC). Through violence risk screening at admission and

early identified risk factors, healthcare professionals might gain better foreknowledge of early warning indicators in order to manage potential increased risk through individualised appropriate interventions.

Two of the six items in the BVC and Item 2 in V-RISK-10 concern threats made to others and might record some of the same phenomena. Hence including Item 2 *Previous and/or current threats* from V-RISK-10 in the extended short-term risk assessment model might explain more of the imminent violence conducted by those patients who tend to threaten others prior to potential violence. Within the framework of developing an extended model of risk prediction, addressing possible differences concerning threat as a precursor to physical violence compared to physical violence without precursor threat needs further investigation.

The explanation for why patients who reported ‘don’t know’ or refused to answer questions about their risk are more likely to increase the prediction of imminent violence in an acute psychiatric setting remains unclear. This alone would benefit from further investigation through qualitative interviews with patients and/or participatory observational studies.

The patient characteristics; male gender, only primary school education, being involuntarily admitted, and violence as caused for the admission, remained significantly associated with inpatient violence during hospitalisation in a separate multivariate logistic regression (see Table 4). When adjusting the extended model for the respective patient characteristics, only gender remained significant (see Table 5). Adding gender to the model gave mixed results according to the fit indices. The explained variance increased, according to the AIC, but not according to the BIC. Adding gender weakened the OR of Item 2 in V-RISK-10, but did not modify the BVC-ordinal, nor the SRS-d. Thus the extended model was not substantially altered by adding gender.

### *Ethical implications*

Inpatient care is affected by the outcomes of violence risk assessments. Categorising patients into low or high risk at admission diverts resources from patients categorised as low risk, even though a significant number of the latter do perpetrate harmful acts (Ryan, Nielssen, Paton, & Large, 2010). Also, the outcome of short-term risk assessments will influence inpatient care, but for a shorter period of time, given the repeated measurements.

False positives and false negatives have significant implications for individual care and the well-being of others (Ryan et al., 2010). Given the potential for false positives and false negatives in risk assessment, determining what is an acceptable level for sensitivity and specificity has been a topic of debate and is an issue that the BVC has to deal with. The choice of cut-off point is of particular importance because of the ethical considerations involved. The cut-off for high risk in BVC-ordinal is elevated compared to the original suggestions (Almvik et al., 2000). The consequence of this is a larger number of false negatives resulting in an increased risk of the healthcare staff and fellow patients being subjected to violence. False positive cases also entail the risk of unnecessary interventions. Conversely, a positive consequence of an elevated cut-off is a decreased number of false positives, hence fewer non-violent patients are stigmatized and exposed to unnecessary de-escalating interventions of a false-negative assessment.

The risk of stigmatizing patients with positive test results requires conscious consideration and should be avoided whenever possible (Rechenmacher et al., 2014). However, interventions made by clinical unstructured measurements of violence do also have ethical implications and risk for stigmatizing patients.

### *Strengths and limitations*

A prospective, naturalistic design increases external validity. A significant sample size and low amounts of missing data are also strengths. The more advanced statistical analyses

with GLMM adjusting for repeated measurements increased the internal validity of the results, although the results are not comparable to previous studies. Data collection in a single hospital site is a limitation related to potential generalisation of results, but also a strength given the number of patients included and the reduced potential for dissimilarities regarding how the nursing staff interpret patients' behaviours and score the BVC. The changed time for conducting the violence risk assessments with the BVC, compared to the original BVC recommendations, complicates comparisons with previous studies, although several other studies used procedures similar to our study. Recordings of SRS and V-RISK-10 made during the admission procedure, which is often a first-time meeting of the patient, is a limitation due to the limited information available and the absence of a trusting relationship. Still, a change in procedure would result in a longer period of time without any risk assessment being done.

The variation in length of admission among patients (from less than one nursing shift to 175 days) and the use of a secondary outcome (any violence during hospitalisation) is a limitation. Longer admissions increase the likelihood of potential violence to occur. Conversely, an extended time between the measures of SRS and V-RISK 10, and the occurrence of violence, reduces the strength of the relationship.

When violence risk assessments indicate high risk, the healthcare staff and nursing staff, in particular, are obliged to implement preventive measures that can mitigate the risk. Such efficient violence risk management after high BVC sum scores may have resulted in "true positive" cases becoming false positives and thereby weakened the overall predictive validity. However, the instigation of preventive measures is an integral and core aspect of this approach.

Underreporting of violence has been identified in previous studies using the SOAS-R (Hvidhjelm, Sestoft, & Bjorner, 2014; Tenneij, Goedhard, Stolker, Nijman, & Koot, 2009). The use of additional sources to gather information from hospital records and hospital

protocols documenting coercive measures may have decreased the risk of underreporting in this study.

### *Conclusion and relevance for clinical practice*

The results from this study indicate that an extended model for short-term risk assessment explains more variance of the imminent violence than the BVC alone. Item 2 *Previous and/or current threats* from the V-RISK-10 contributed more in the explanation of imminent violence, compared to the contribution of SRS. Further studies are recommended to investigate whether an extended model for short-term risk assessment which includes different approaches and perspectives would provide better violence risk prediction than short-term risk assessments with the BVC alone. Further studies are also recommended to investigate whether implementing an extended short-term risk assessment model reduces inpatient violence more compared to implementing a single short-term risk assessment instrument.

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Table1

*Distribution of patient characteristics divided between violent and non-violent patients*

| Variable | All (%) | Violent (%) | Non-violent (%) | Test value | *P* |
|---|---|---|---|---|---|
| Patients *(n)* | 508 | 73 (14.4%) | 435 (85.6%) | | |
| **Sociodemographic variables** | | | | | |
| Gender | | | | 5.74 (1) [a] | <0.001 |
| Men, *n* (%) | 227 (44.7%) | 47 (20.7%) | 180 (79.3%) | | |
| Women, *n* (%) | 281 (55.3%) | 26 (9.3%) | 255 (90.7%) | | |
| Age (years), mean/median | 40.82 / 38 | 40.92 / 37 | 40.80 / 38 | -0.6 [b] | 0.936 |
| Not in relationship (4.3% missing) | 361 (74.3%) | 57 (15.8%) | 304 (84.2%) | 3.78 (1) [a] | 0.052 |
| Only primary school (12.80% missing) | 148 (33.4%) | 34 (23.0%) | 114 (77.0%) | 10.67 (1) [a] | 0.001 |
| Unemployed (excluding age retirement) (9.65% missing) | 323 (70.4%) | 61 (18.9%) | 262 (81.1%) | 11.14 (1) [a] | <0.001 |
| Main diagnoses according to ICD 10 | | | | 33.34 (6) [a] | <0.001 |
| F10-19 | 84 (16.5%) | 16 (19.0%) | 68 (81.0%) | 1.79 (1) [a] | 0.181 |
| F20-29 | 129 (25.4%) | 35 (27.1%) | 94 (72.9%) | 22.89 (1) [a] | <0.001 |
| F30-31 | 56 (11.0%) | 8 (14.3%) | 48 (85.7%) | 0.00 (1) [a] | 0.985 |
| F32-39 | 62 (12.2%) | 4 (6.5%) | 58 (93.5%) | [c] | 0.079 |
| F40-49 | 67 (13.2%) | 2 (3.0%) | 65 (97.0%) | [c] | 0.002 |
| F60-69 | 47 (9.3%) | 3 (6.4%) | 44 (93.6%) | [c] | 0.126 |
| Other or no diagnoses | 63 (12.4%) | 5 (7.9%) | 58 (92.1%) | 2.42 (1) [a] | 0.120 |
| **Variables related to the hospital stay** | | | | | |
| Stay days mean/median | 16.16 / 4 | 40.58 / 33 | 12.07 / 3 | -7.78 [d] | <0.001 |
| Involuntarily referred [e] | 213 (41.9%) | 57 (26.8%) | 156 (73.2%) | 45.76 (1) [a] | <0.001 |
| Involuntarily admitted [e] | 135 (26.6%) | 49 (36.3%) | 86 (63.7%) | 71.83 (1) [a] | <0.001 |
| Violence as cause for the admission [f] | | | | 20.80 (2) [a] | <0.001 |
| No | 437 (87.1%) | 50 (11.4%) | 387 (88.6%) | | |
| Yes | 52 (10.4%) | 16 (30.8%) | 36 (69.2%) | | |

ICD 10 = International Statistical Classification of Diseases and Related Health Problems 10th Revision.

[a] Chi-square test, χ2 (df). [b] Independent samples *t*-test (t-value). [c] Fisher's Exact Test. [d] Mann-Whiney *U* test (Z-value).

[e] According to the Norwegian Mental Health Care Act of 1999, an individual can be referred to inpatient psychiatric care either voluntarily or involuntarily. For patients referred involuntarily, the institution must ensure during the first 24 hours that a psychiatrist or clinical psychologist affirms the legal basis for the admission. An involuntarily admitted patient can be retained either on observational status (up to 10 days) or under long-term detention. [f] 3.74% of the observations excluded (1.18% missing and 2.56% recorded as don't know).

Table 2

*Association of BVC-ordinal sum score with imminent violence by Generalised Linear Mixed Model analyses*

| | **OR** | **95% CI** | ***p*** |
|---|---|---|---|
| **BVC-ordinal sum score** | | | <0.001 |
| 0 (ref) | - | - | - |
| 1-3 | 3.45 | (2.41-4.94) | <0.001 |
| 4-6 | 20.46 | (13.20-31.72) | <0.001 |

BVC = Broset Violence Checklist

Table 3

*Association of single items in V-RISK-10 with violent behaviour during hospitalisation by logistic regression*

| | | Univariate analyses | | | Multivariate analyses | | |
|---|---|---|---|---|---|---|---|
| | ***N* (%)** | **OR** | **95% CI** | ***P*** | **OR** | **95% CI** | ***P*** |
| 1-Previous and/or current violence | | | | <0.001 | | | |
| Maybe/moderate/don't know | 151 (29.7) | 4.81 | (2.47-9.39) | <0.001 | | | |
| Yes | 82 (16.1) | 9.67 | (4.78-19.57) | <0.001 | | | |
| 2-Previous and/or current threats | | | | <0.001 | | | <0.001 |
| Maybe/moderate/don't know | 150 (29.5) | 5.09 | (2.45-10.57) | <0.001 | 3.37 | (1.58-7.19) | 0.002 |
| Yes | 103 (20.3) | 10.93 | (5.27-22.69) | <0.001 | 6.98 | (3.27-14.90) | <0.001 |
| 3-Previous and/or current substance abuse | | | | 0.019 | | | |
| Maybe/moderate/don't know | 94 (18.5) | 2.10 | (1.06-4.16) | 0.034 | | | |
| Yes | 182 (35.9) | 2.18 | (1.23-3.88) | 0.008 | | | |
| 4-Previous and/or current major mental illness | | | | <0.001 | | | |
| Maybe/moderate/don't know | 122 (24.1) | 4.50 | (1.92-10.53) | 0.001 | | | |
| Yes | 204 (40.2) | 5.95 | (2.72-13.02) | <0.001 | | | |
| 5-Personality disorder | | | | 0.376 | | | |
| Maybe/moderate/don't know | 243 (47.9) | 1.06 | (0.62-1.82) | 0.823 | | | |
| Yes | 53 (10.5) | 1.71 | (0.79-3.71) | 0.173 | | | |
| 6-Lack of insight into illness or behaviour | | | | <0.001 | | | |
| Maybe/moderate/don't know | 171 (33.8) | 4.58 | (1.82-11.56) | 0.001 | | | |
| Yes | 153 (30.2) | 11.91 | (4.91-28.87) | <0.001 | | | |
| 7-Expresses suspicion | | | | <0.001 | | | <0.001 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Maybe/moderate/don’t know | 152 (30.0) | 6.86 | (3.45-13.65) | <0.001 | 4.56 | (2.23-9.34) | <0.001 |
| Yes | 87 (17.2) | 8.13 | (3.86-17.13) | <0.001 | 5.30 | (2.44-11.54) | <0.001 |
| 8-Shows lack of empathy | | | | <0.001 | | | |
| Maybe/moderate/don’t know | 147 (29.1) | 6.12 | (3.44-10.90) | <0.001 | | | |
| Yes | 33 (6.5) | 7.65 | (3.26-17.96) | <0.001 | | | |
| 9-Unrealistic planning | | | | <0.001 | | | |
| Maybe/moderate/don’t know | 218 (43.0) | 4.47 | (2.23-8.94) | <0.001 | | | |
| Yes | 73 (14.4) | 7.07 | (3.19-15.65) | <0.001 | | | |
| 10-Future stress situations | | | | 0.013 | | | |
| Maybe/moderate/don’t know | 225 (44.3) | 2.75 | (1.18-6.41) | 0.019 | | | |
| Yes | 168 (33.1) | 3.63 | (1.54-8.54) | 0.003 | | | |

V-RISK-10 = Violence Risk Screening-10.

Table 4:

*Association of patient characteristics with violent behaviour during hospitalisation by logistic regression*

| | Univariate analyses | | | Multivariate analyses | | |
|---|---|---|---|---|---|---|
| | **OR** | **95% CI** | ***P*** | **OR** | **95% CI** | ***P*** |
| **Sociodemographic variables** | | | | | | |
| Male gender | 2.56 | (1.53-4.29) | <0.001 | 2.69 | (1.36-5.29) | 0.004 |
| Only primary school | 2.37 | (1.40-4.01) | 0.001 | 2.60 | (1.33-5.08) | 0.005 |
| Unemployed (excluding age retirement) | 3.29 | (1.58-6.83) | 0.001 | | | |
| Main diagnosis according to ICD 10 [a] | | | <0.001 | | | |
| F10-19 | 2.73 | (0.94-7.91) | 0.064 | | | |
| F20-29 | 4.32 | (1.60-11.65) | 0.004 | | | |
| F30-31 | 1.93 | (0.59-6.30) | 0.274 | | | |
| F32-39 | 0.80 | (0.20-3.13) | 0.749 | | | |
| F40-49 | 0.36 | (0.07-1.91) | 0.229 | | | |
| F60-69 | 0.79 | (0.18-3.49) | 0.757 | | | |
| **Variables related to the hospital stay** | | | | | | |
| Stay days | 1.04 | (1.03-1.05) | <0.001 | 1.04 | (1.02-1.05) | <0.001 |
| Involuntarily referred [b] | 6.37 | (3.54-11.47) | <0.001 | | | |
| Involuntarily admitted [b] | 8.29 | (4.82-14.25) | <0.001 | 3.00 | (1.49-6.08) | 0.002 |
| Violence as caused for the admission | 3.44 | (1.78-6.65) | <0.001 | 2.73 | (1.17-6.40) | 0.020 |

ICD 10 = International Statistical Classification of Diseases and Related Health Problems 10th Revision

[a] Other or no diagnosis as reference. [b] According to the Norwegian Mental Health Care Act of 1999, an individual can be referred to inpatient psychiatric care either voluntarily or involuntarily. For patients referred involuntarily, the institution must ensure during the first 24 hours that a psychiatrist or clinical psychologist affirms the legal basis for the admission. An involuntarily admitted patient can be retained either on observational status (up to 10 days) or under long-term detention.

Table 5

*Stepwise multivariate generalised mixed model analyses of BVC, the extended model and the extended model controlled for other variables*

| | OR | 95% CI | *P* | *AIC* | *BIC* |
|---|---|---|---|---|---|
| **Step 1: BVC alone:** | | | | **2089.01** | **2121.14** |
| BVC (sum score of 0 as reference) | | | <0.001 | | |
| Sum score 1-3 | 3.45 | (2.41-4.94) | <0.001 | | |
| Sum score 4-6 | 20.46 | (13.20-31.72) | <0.001 | | |
| **Step 2: BVC + SRS-d:** | | | | **2079.63** | **2119.80** |
| BVC (sum score of 0 as reference) | | | <0.001 | | |
| Sum score 1-3 | 3.31 | (2.32-4.74) | <0.001 | | |
| Sum score 4-6 | 19.26 | (12.46-29.79) | <0.001 | | |
| SRS-d | 2.89 | (1.54-5.44) | 0.001 | | |
| **Step 3: BVC + SRS-d + item 2 from V-RISK-10 [a]:** | | | | **2053.54** | **2109.78** |
| BVC (sum score of 0 as reference) | | | <0.001 | | |
| Sum score 1-3 | 3.00 | (2.11-4.27) | <0.001 | | |
| Sum score 4-6 | 17.22 | (11.24-26.39) | <0.001 | | |
| SRS-d | 2.01 | (1.09-3.70) | 0.025 | | |
| V-RISK-10, Item2: Previous and/or current threats | | | <0.001 | | |
| Maybe/moderate/don't know | 5.05 | (2.35-10.87) | <0.001 | | |
| Yes | 7.49 | (3.32-16.89) | <0.001 | | |
| **Step 3: controlled for gender [b]:** | | | | **2050.50** | **2114.78** |
| BVC (sum score of 0 as reference) | | | <0.001 | | |
| Sum score 1-3 | 2.99 | (2.10-4.25) | <0.001 | | |
| Sum score 4-6 | 17.25 | (11.25-26.45) | <0.001 | | |
| SRS-d | 2.12 | (1.16-3.89) | 0,015 | | |
| V-RISK-10, Item2: Previous and/or current threats | | | <0.001 | | |
| Maybe/moderate/don't know | 4.58 | (2.13-9.82) | <0.001 | | |
| Yes | 6.02 | (2.65-13.67) | <0.001 | | |
| Male gender | 1.93 | (1.08-3.45) | 0.026 | | |

BVC = Broset Violence Checklist. SRS = Self-report Risk Scale. AIC = Akaike's information criterion. BIC = Bayesian information criterion. V-RISK-10 = Violence Risk Screening-10

[a] Item 7 in V-RISK-10 became non-significant. [b] The following patient characteristics became non-significant: Only primary school, Stay days, Involuntary admitted and Violence as caused for the admission.