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ORIGINAL ARTICLE

Crime, mortality and neurocognitive disorders: A nationwide register study in Finland

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Abstract

Objectives: To explore mortality of patients with Alzheimer's disease (AD), frontotemporal dementia (FTD), or Lewy body dementias (LBD) who had criminal behavior in the year preceding diagnosis.

Methods: Data were obtained from the nationwide registers. Mortality was compared between disorder groups with and without criminal acts and with the general population. The cohort included patients who had received a discharge register diagnosis of AD (N = 80,540), FTD (N = 1060), or LBD (N = 10,591) between 1998 and 2015. The incidences of crimes were calculated in the year preceding diagnosis. We further calculated age- and sex-adjusted survivals of different dementia groups with and without criminal acts, and in relation to the general population (SMR, Standardized Mortality Ratio).

Results: Criminal behavior was more common in men than in women. It was associated with decreased mortality in the AD group. SMRs due to unnatural causes, and in the LBD and FTD female groups, were higher in patients with criminal behavior than in those without.

Conclusion: LBD and female FTD patients, who had criminal behavior before diagnosis, were at higher risk of death than patients without such behavior. Novel criminality in older adults may be associated with neurocognitive disorder, in which case medical attention is justified.

KEYWORDS
behavior, dementia, mortality

1 | INTRODUCTION

Worldwide, nearly 50 million people have received a diagnosis of neurocognitive disorder and around 90% of them suffer from behavioral and psychological symptoms of dementia (BPSD) at some stage of their illness (Bang et al., 2015; Kurz et al., 2014). Symptoms usually start with difficulties in everyday functioning, oversights, or changes in mood and cognition, but they may also begin with BPSD, resulting in behavioral disturbances or even criminal acts (Shinagawa et al., 2017; Talaslahti et al., 2021).

Neurocognitive disorder is an independent risk factor for premature death (Chan et al., 2013; Garcia-Ptacek et al., 2014; Park et al., 2014; Steenland et al., 2010). In the literature, excess mortality for dementia is associated with age, male sex, high number of medications, lower cognition measured by Mini Mental State Examination, institutionalization, and somatic comorbidities, especially cardiovascular diseases and infections. Higher mortality is also associated with serious neuropsychiatric symptoms such as psychosis and inpatient psychiatric care (Charlson et al., 2010; Goluke et al., 2020; Vilalta-Franch et al., 2013; Wetmore et al., 2019). Shorter survival is expected in patients suffering from comorbid diseases before diagnosis (White et al., 2020).

Criminal behavior in patients with neurocognitive disorder is sparsely studied, especially an association between criminality and mortality. As some features in neurocognitive disorders, such as psychotic symptoms, are associated with higher mortality, we decided to study whether there is also an association between criminality and mortality. In addition, our previous study showed risk behavior in patients with neurocognitive disorders preceding diagnosis, we wanted to explore how such behavior during a 1-year period before the diagnosis could influence mortality after diagnosis (Talaslahti et al., 2021). A period of 1 year was chosen because criminal acts during this time period were most likely associated with a neurocognitive disorder (Talaslahti et al., 2021). Crime was defined as any type of offence that was against the Finnish legislation and recorded in the Finnish Police Register. Our aim was to study overall mortality and causes of death in patients with Alzheimer's disease (AD), frontotemporal dementia (FTD), and Lewy body dementias (LBD, including Parkinson's disease dementia and dementia with Lewy bodies) who had had crime notes in the Police Register preceding diagnosis. Furthermore, we compared the results with dementia patients without such criminal behavior and also with the same-aged general population.

2 | MATERIALS AND METHODS

2.1 | Information on diagnostics and criminal acts

Data on diagnostics and criminal acts were received from the nationwide registers: the Finnish Care Register for Health Care (former Finnish Hospital Discharge Register) and the Finnish Police Register, as previously described (Elonheimo et al., 2014; Sund, 2012; Talaslahti et al., 2021). Offenses of various severity levels (minor, basic, aggravated) were merged in the same group with the exception of small or very small traffic (minor) offenses which were totally excluded as they were not classified as crimes according to the Finnish legislation.

We received the main discharge diagnoses of neurocognitive disorders from all hospital and primary outpatient care between 1998 and 2015. All cases with ICD-10 diagnoses of AD (F00 and/or G30 codes), FTD (F02.0 and/or G31.0 codes), Parkinson's disease dementia (F02.3 and/or G20 codes), and dementia with Lewy bodies (F02.8 and/or G31.8 codes) were included in our study. Cases with other types of dementia, such as vascular dementia, dementia of unknown origin, alcohol dementia, or head injuries, were excluded due to their heterogenic nature.

2.2 | Information on mortality

Information on causes of death was based on death certificates provided by Statistics Finland. In this register, classification of the causes of death is based on the diseases known before death or on a post-mortem examination. The latter is performed when a cause of death remain unknown or death has happened accidently. Statistics on the causes of death refer to the Finnish Classification of Diseases using ICD-10 diagnostic codes. The classification is divided in to natural causes, such as various physical diseases, and unnatural causes, such as suicides (ICD-10: X60–X84), homicides (ICD-10: 85– Y871), and accidents (ICD-10: V01–X59, Y10–Y86, Y972, and Y88–Y89).

2.3 | Study population

The total number of patients with neurocognitive disorder was 92,161, including 80,540 patients with AD (53,028 women, 27,512 men), 1060 patients with FTD (604 women, 456 men), and 10,591 patients with LBD (5265 women, 5326 men). Cases with two diagnoses were examined and the main diagnosis was chosen according to the clinical picture and also according to further diagnosis. A patient was included in the group with criminal behavior if he or she had committed at least one crime during a 1-year period before the diagnosis of neurocognitive disorder. The actual study period and the patient enrollment ended up in 2015. However, data on mortality was followed up until the end of 2018. All data were linked by the personal identification number that every Finnish citizen has. Thus, the cases could not be identified in the data.

2.4 | Data analysis

Data are presented as means with standard deviation and as counts with percentages. Comparisons among groups were made with the Student's *t*-test for continuous variables and the Chi-square test for categorical variables. The Kaplan-Meier method was applied to estimate cumulative mortality, which was compared between groups with the log-rank test. Age- and sex-adjusted Kaplan-Meier cumulative mortality rates were estimated using two propensity score-based techniques, stratification and weighting (MMWS, marginal mean weighting through stratification) (Linden, 2014). Marginal mean weighting through stratification is an extension of propensity score matching that combines propensity score stratification and inverse probability of treatment weighting. Cox proportional hazards regression was used to estimate the sex-adjusted hazard ratios (HRs) and their 95% confidence intervals (CIs), with age as the underlying time scale. The proportional hazards assumption was tested

graphically and by use of a statistical test based on the distribution of Schoenfeld residuals. Standardized mortality ratios (SMRs) were used to quantify the risk of death in this cohorts compared with the in Finland general population. Standardized mortality ratio was calculated in relation to the age- and sex-matched general population (Armitage et al., 2002). Standardized mortality ratio (SMR), that is, the ratio of observed to expected number of deaths, was calculated using subject-years methods with 95% confidence intervals (CIs). The expected number was determined by multiplying the person-years of observation by the appropriate mortality rate in the general population according to the categories of sex, 1-year age group, and calendar period (from 1998 to 2018). Statistical comparison between SMRs was made by using Poisson regression models. Furthermore, SMRs of disorder groups with and without criminal behavior were also compared. The Poisson regression models were evaluated using goodness-of-fit test, and the assumptions of overdispersion in models were tested using the Lagrange multiplier test. Probabilities of survival in an age- and sex-matched sample of the general population were calculated from data of the Official Statistics of Finland from Statistics Finland. Stata 17.0 (StataCorp LP; College Station, TX, USA) statistical package was used for the analysis.

3 | RESULTS

3.1 | General information

In the year preceding diagnosis, criminal behavior was more common in men than in women in all three neurocognitive disorder groups. The number of men and women who committed at least one crime was 3.7% and 0.4% ($p < 0.001$) in the AD group, 7.7% and 2.3% ($p < 0.001$) in the FTD group, and 3.6% and 0.5% ($p < 0.001$) in the LBD group, respectively. Crime types are described in Figure 1. In AD, the mean age at diagnosis was 76 years in patients who committed crimes and 81 years in the group without crimes ($p < 0.001$). The mean ages at diagnosis in the FTD group were 67 and 71 years ($p < 0.001$) and in the LBD group 62 and 73 years ($p < 0.001$) in persons with and without criminal behavior, respectively. General information on the study population is presented in Table 1.

3.2 | Influence of criminal behavior on mortality

Firstly, we calculated age- and sex-adjusted mortality of different dementia groups with and without criminal acts. Criminal behavior was associated with decreased mortality in the AD group, that is, the mortality of the AD patients who committed crimes was lower as compared to those who did not commit crimes: age- and sex-adjusted Hazard Ratio (HR) was 0.82 (95% CI: 0.76–0.88, $p < 0.001$). In FTD and LBD, HRs were 0.74 (95% CI: 0.50–1.10, $p = 0.14$) and 0.91 (0.76–1.09, $p = 0.31$), respectively (Figure 2).

3.2.1 | Mortality ratios compared with the general population

Secondly, we calculated SMR. It was higher in both female and male LBD patients with criminal behavior than in LBD patients without such behavior (Table 2). The SMR was also higher in FTD women with criminal acts than in FTD women without such acts. In FTD men and in AD men and women, the differences between the SMRs of patients with and without criminal manifestations were not significant (Table 2).

3.2.2 | Causes of death

In the dementia groups with criminal acts, 87% of all deaths were due to natural causes and 13% due to unnatural causes. The most common causes of death were dementias accounting for 52% (AD 52%, FTD 70%, LBD 44%), circulatory diseases for 24% (AD 25%, FTD

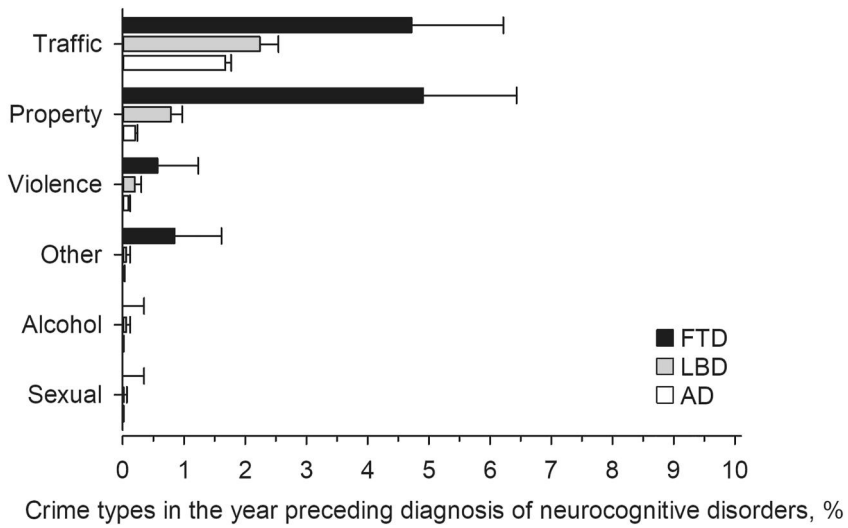

FIGURE 1 Distribution of crime types in the year preceding diagnosis of neurocognitive disorders. Error bars represent 95% confidence intervals. AD, Alzheimer's disease; FTD, frontotemporal dementia; LBD, Lewy body dementias (Parkinson's disease dementia and dementia with Lewy bodies)

TABLE 1 General information on groups of neurocognitive disorder with and without criminal behavior in the year preceding diagnosis

	Crime in the year preceding diagnosis		
	No	Yes	*p*-value
AD			
Number	79,296	1244	NA
Women, *n* (%)	52,801 (67)	227 (18)	<0.001
Mean age at diagnosis, mean (SD)	81 (7)	76 (8)	<0.001
Person-years followed up	339,201	5792	NA
Number of death	60,754	784	NA
Crude mortality, % (95% CI)			$p < 0.001$
5 years	56.9 (56.5–57.2)	46.4 (43.5–49.4)	
10 years	87.0 (86.7–87.3)	82.2 (78.7–85.4)	
15 years	97.2 (96.9–97.4)	95.9 (91.6–98.3)	
FTD			
Number	1011	49	NA
Women, *n* (%)	590 (58)	14 (29)	<0.001
Mean age at diagnosis, mean (SD)	71 (10)	67 (9)	0.001
Person-years followed up	4587	278	NA
Number of death	619	27	NA
Crude mortality, % (95% CI)			0.070
5 years	48.2 (45.0–51.6)	30.5 (19.2–46.3)	
10 years	78.5 (74.6–82.2)	72.7 (55.2–87.8)	
15 years	91.1 (86.1–94.8)	86.4 (60.5–98.6)	
LBD			
Number	10,362	229	NA
Women, *n* (%)	5226 (50)	39 (17)	<0.001
Mean age at diagnosis, mean (SD)	73 (11)	62 (12)	<0.001
Person-years followed up	46,255	1255	NA
Number of death	7913	124	NA
Crude mortality, % (95% CI)			<0.001
5 years	58.5 (57.6–59.5)	39.7 (33.5–46.5)	
10 years	80.8 (79.9–81.7)	60.6 (53.5–67.8)	
15 years	91.0 (89.8–92.0)	60.6 (53.5–67.8)	

Abbreviations: AD, Alzheimer's disease; CI, confidence interval; FTD, frontotemporal dementia; LBD, Lewy body dementias (Parkinson's disease dementia and dementia with Lewy bodies); NA, Not applicable; SD, standard deviation.

19%, LBD 20%), and cancer for 11% (AD 11%, FTD 4%, LBD 10%) of all deaths. Deaths due to unnatural causes were more common in patients with neurocognitive disorders with criminal behavior than in patients without such behavior, especially in the group of LBD patients (Table 2). There were 47 suicides in the AD group as a whole, but five suicides in the criminal group, four by hanging or self-suffocating and one by shooting with a gun. In the LBD group, we found 18 suicides, three of which were in the group with criminal acts. No suicides were found in the FTD group. Violent deaths were rare there were four murders or manslaughters in the AD group without criminal activity and one in the LBD group with criminal acts.

4 | DISCUSSION

A novel finding in our registry-based study was that compared with the general population, LBD patients and female FTD patients with criminal behavior in the year preceding diagnosis showed higher

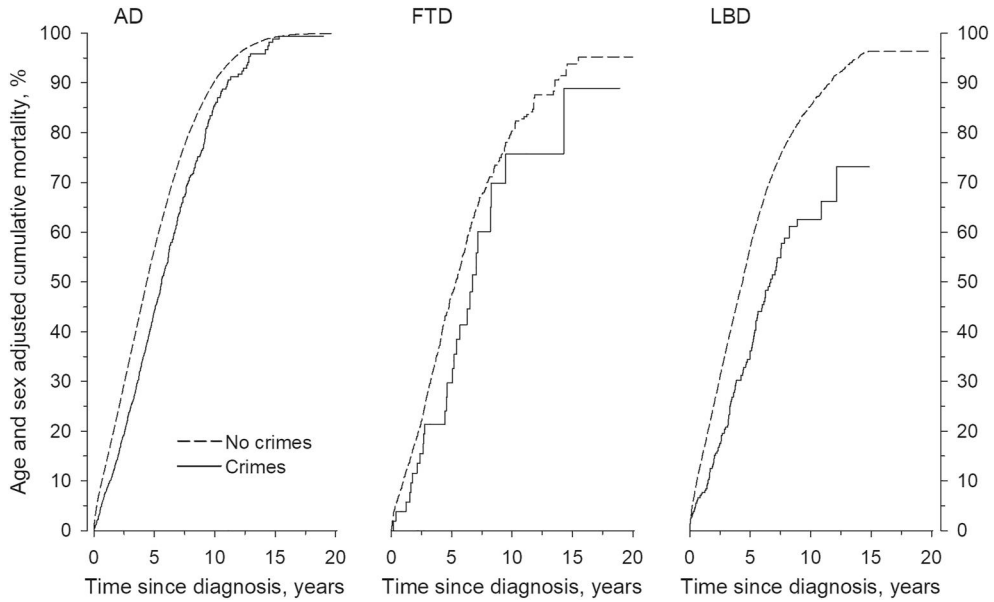

FIGURE 2 Age and sex adjusted cumulative mortality of different groups of neurocognitive disorders (AD, FTD, LBD) with and without criminal behavior in the year preceding diagnosis. AD, Alzheimer's disease; FTD, frontotemporal dementia; LBD: Lewy body dementias (Parkinson's disease dementia and dementia with Lewy bodies)

TABLE 2 Standardized mortality ratios (SMRs) in different neurocognitive disorders

	Crime in the year preceding diagnosis		
	No SMR (95% CI)	Yes SMR (95% CI)	*p*-value
AD			
All	2.14 (2.12–2.16)	2.18 (2.02–2.33)	0.63
Women	2.04 (2.02–2.06)	2.03 (1.64–2.41)	0.94
Men	2.35 (2.31–2.38)	2.20 (2.03–2.37)	0.11
FTD			
All	3.70 (3.39–4.00)	3.64 (2.21–5.08)	0.64
Women	3.46 (3.08–3.85)	12.58 (4.43–20.73)	<0.001
Men	4.01 (3.53–4.50)	2.57 (1.32–3.82)	0.081
LBD			
All	3.99 (3.90–4.09)	5.65 (4.63–6.67)	<0.001
Women	3.68 (3.55–3.80)	7.42 (3.40–11.44)	0.011
Men	4.34 (4.20–4.48)	5.50 (4.45–6.55)	0.016
Unnatural causes of death			
All	1.95 (1.87–2.04)	2.83 (2.12–3.76)	0.012
AD	1.82 (1.73–1.91)	2.19 (1.55–3.10)	0.30
FTD	1.77 (1.01–3.12)	2.33 (0.33–10.54)	0.79
LBD	3.51 (3.12–3.94)	8.80 (5.21–14.86)	<0.001

Abbreviations: AD, Alzheimer's disease; CI, confidence interval; FTD, frontotemporal dementia; LBD, Lewy body dementias (Parkinson's disease dementia and dementia with Lewy bodies); SMR, standardized mortality ratio.

mortality after diagnosis than the patients without such behavior. Other important findings were that criminal acts were more common in men than in women in every group of neurocognitive disorders, that is, AD, FTD, and LBD. The most frequent causes of death, such as dementias, circulatory diseases, and cancers, were similar to those in the older Finnish general population (Statistics Finland). However, patients with neurocognitive disorders and criminal behavior preceding diagnosis died of unnatural causes of death 1.5–fold more often than dementia patients without criminal acts and compared with the same-aged general population.

4.1 | Standardized mortality ratios

Mortality ratios compared with the same-aged general population were elevated in all three groups of neurocognitive disorders. This is in line with the previous American study of Steenland et al. (2010), in which the SMR was 1.70 for probable AD and 3.47 for FTD. For dementia with Lewy bodies and Parkinson's disease dementia, SMRs were 2.4 and 2.0, respectively. In our study, SMRs for these disorders were 2.14 (AD) and 3.70 (FTD), but SMR was almost two-fold, that is, 3.99, in the LBD group (including dementia with Lewy bodies and Parkinson's disease dementia). The discrepancy between study results may be explained by different study populations and study protocols.

We found that the SMR for LBD patients was almost 1.5-fold higher and the SMR for FTD women was threefold higher in the group with criminal acts compared with the group without criminal acts. We found no previous literature concerning mortality in dementia patients who had committed crimes. In a nationwide

Norwegian study of criminal offenders without dementia aged from 15 to 69 years, age-adjusted risk of death was 2.5 times higher for female offenders and 2.1 times higher for male offenders relative to non-offenders. These individuals had not served a prison sentence or had any record of drug-related offences (Skardhamar & Skirbekk, 2013). That study shows that the likelihood of premature death normally increases if someone has committed crimes. However, the social situation of these individuals and their reasons for such behavior probably differ from those of patients with neurodegenerative disease.

4.2 | Survival

Patients who had committed crimes preceding diagnosis of AD had better survival than AD patients without criminal acts during that time. In the literature, BPSD has been associated with worse survival. In a registry study by Bränsvik and colleagues (Bränsvik et al., 2020) using the Swedish BPSD registry, Hazard Ratio (HR) was 1.31 (95% CI 1.08–1.60) and 1.74 (95% 1.44–2.12) for moderate score and severe score in the Neuropsychiatric Inventory, respectively, compared with patients with no mention in the BPSD registry.

Increased criminal and inappropriate behavior have been associated especially with diagnosed frontotemporal degeneration but also with Alzheimer's dementia (Diehl-Schmid et al., 2013; Liljegren et al., 2015, 2018; Shinagawa et al., 2017). In a previous Dutch study of dementia patients in psychiatric care, absolute mortality risk was high compared with the general population, but comorbid psychiatric diagnosis, such as schizophrenia, mood disorders, or personality disorders, did not increase the risk (Goluke et al., 2020). Criminal behavior in neurocognitive disorders is usually associated with BPSD, and younger age at diagnosis or symptom onset has been related to longer survival (Gerritsen et al., 2019). In our study, the better survival in AD patients with criminal acts may have been due to a fairly good functional capacity of these patients, though the study the study gives no direct answer to this. In some cases, the criminal act may have led to earlier diagnosis which may contribute to better survival.

4.3 | Causes of death

In our study, half of the deaths resulted from dementias, some 25% died from diseases of the circulatory system, and 10% from cancers. In Finland, dementias were the third most common cause of death (22% in the older population), while circulatory diseases accounted for 38% and cancers 26% of all deaths in 2018 (Statistics Finland 2018). In a recent study of a population with cognitive impairment, multimorbidity was a common finding in postmortem examinations (Schiltz et al., 2019). Thus, prevention and good care of risk factors for dementia, such as heart disease, may reduce mortality (Vassilaki et al., 2015).

Unnatural causes of death were over-represented in patients with neurocognitive disorders with criminal behavior preceding diagnosis. In this study, SMR for unnatural causes of death in patients with neurocognitive disorders with criminal behavior was twice as high as in patients without criminal acts. The finding is in line with a Finnish study of younger offenders without dementia, whose mortality was higher than in the group of non-offenders (Elonheimo et al., 2017). In a South-Korean study of patients with cognitive impairment, the overall SMR for accidents was 1.44 (95% CI 1.22–1.71), and older age and later onset increased the risk (An et al., 2019). In our study, violent deaths or suicides were rare. The finding is similar to a previous review that had, concluded that the suicide rate in patients with neurocognitive disorders is even lower than in the general population (Haw et al., 2009). However, evidence for this conclusion is lacking, and the earlier studies had methodological limitations (Diehl-Schmid et al., 2013). It seems that patients who are younger, at an early stage of their illness, or have received their diagnosis in hospital care are at greater risk for suicidal death (Haw et al., 2009). Thus, suicidal behavior is possible, but the neurocognitive disorder itself has an influence on the ability to commit suicide (Brooks et al., 2019).

4.4 | Strengths and limitations

This study was based on high quality databases (Lahti & Penttilä, 2001; Sund, 2012). The Finnish Care Register for Health Care covers all Finnish patients with AD, FTD, and LBD who were diagnosed in special level hospital and outpatient care or in primary care from 1998 to 2015. As a register study, we are highly dependent on the quality of the register data. Although the quality of the used registers has been reported to be high, we cannot totally exclude selection bias, information bias and confounders. Moreover, all reports directed to the police are recorded in the Police Register, even if they do not result in a conviction (Elonheimo et al., 2014, 2017; Shinagawa et al., 2017; Talaslahti et al., 2021). Thus, the definition of a crime was not ambiguous but was in accordance with the law. The Finnish Causes-of-Death Register has previously been shown to be reliable for research purposes (Lahti & Penttilä, 2001). In Finland, all deaths are confirmed by a physician and a postmortem examination is performed if the cause of death remains uncertain. The large number of cases and the long follow-up time are other notable strengths of our study.

Due to the nature of a registry study, we were unable to verify whether the diagnoses were accompanied by neuropathological examinations. Therefore, some cases may have been categorized to a wrong diagnosis group. Medical diagnosis of neurocognitive disorders has, however, improved over the last decades, especially after the year 2006, when the first Finnish Current Guidelines for Alzheimer's diseases were published, with a supplement of other dementias published in 2010. The amount or type of possible BPSD, medications, alcohol and tobacco consumptions, comorbidities, severity level of dementia, or social factors, such as income level or marital status, were not available from the registries.

In summary, this nationwide comprehensive registry study of patients with neurocognitive disorders found that patients with LBD

or female patients with FTD who had criminal behavior in the year preceding diagnosis had an elevated risk of death after diagnosis relative to patients without criminal activity. When all groups of neurocognitive disorders were considered, men committed more crimes than women. Traffic offences and crimes against property were the frequent types of criminal acts. Unnatural causes of death were more common in the group of disorders with criminal acts, thus, elevated mortality in the criminality group may be due to a more severe pathophysiology.

In neurocognitive disorders, criminal behavior preceding diagnosis may predict worse prognosis and increased mortality, especially in LBD. Emerging inappropriate behavior in previously healthy older adults may be a warning sign for incipient dementia, and neurological examinations should be considered. Early diagnosis of dementia may result in adequate treatment and improved prognosis.

AUTHOR CONTRIBUTIONS

Tiina Talaslahti: Conceptualization, funding acquisition, visualization, writing – original draft; **Milena Ginters**: Conceptualization, visualization, writing – original draft; **Hannu Kautiainen**: Conceptualization, formal analysis, methodology, visualization, writing – original draft; **Risto Vataja**: Conceptualization, visualization, writing – original draft; **Anniina Palm**: Conceptualization, visualization, writing – original draft; **Henrik Elonheimo**: Conceptualization, writing – review and editing; **Jaana Suvisaari**: Conceptualization, writing – review and editing; **Nina Lindberg**: Conceptualization, visualization, writing – original draft; **Hannu Koponen**: Conceptualization, funding acquisition, project administration, visualization, writing – original draft.

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CONFLICT OF INTEREST

The authors report no conflicts of interest.

DATA AVAILABILITY STATEMENT

Research data are not shared.

ETHICS STATEMENT

The study protocol was approved by the Ethics Committee of Helsinki University Central Hospital (no. 186/13/03/00/16). No informed consent was required.

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