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Criminal Behavior in the Four Years Preceding Diagnosis of Neurocognitive Disorder: A Nationwide Register Study in Finland

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ABSTRACT

Objective: To explore the criminality of patients with subsequent diagnosis of Alzheimer's disease (AD), frontotemporal dementia (FTD), or Lewy body dementias (LBD) in the four years preceding diagnosis. **Design:** Nationwide register study. **Setting:** Data on Finnish patients were collected from the discharge register and data on criminal offending from the police register. Research findings were compared with the same-aged general population. **Participants:** A total of 92,191 patients who had received a diagnosis of AD ($N = 80,540$), FTD ($N = 1,060$), and LBD ($N = 10,591$) between 1998 and 2015. **Measurements:** Incidences and types of crimes, the standardized criminality ratio (number of actual crimes per number of expected crimes), and the numbers of observed cases and person-years at risk counted in five-year age groups and separately for both genders and yearly. **Results:** At least one crime was committed by 1.6% of AD women and 12.8% of AD men, with corresponding figures of 5.3% and 23.5% in FTD, and 3.0% and 11.8% in LBD. The first crime was committed on average 2.7 (standard deviation 1.1) years before the diagnosis. The standardized criminality ratio was 1.85 (95% confidence interval [CI] 1.43–2.37) in FTD women and 1.75 (95% CI 1.54–1.98) in FTD men, and in AD

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1.11 (95% CI 1.04–1.17) and 1.23 (95% CI 1.20–1.27), respectively. Traffic offences and crimes against property constituted 94% of all offences. **Conclusion:** Criminal acts may occur several years prior to the diagnosis of dementia. If novel criminality occurs later in life, it may be associated with neurocognitive disorder. (Am J Geriatr Psychiatry 2020; ■■■:■■■–■■■)

OBJECTIVE

Around 5% to 8% of people aged 60 years or over suffer from neurocognitive disorders worldwide, totalling 50 million patients in 2019.¹ Of these patients, up to four-fifths have behavioral and psychological symptoms at some stage of their illness. However, type, timing, and focus of these symptoms vary between individuals and different types of dementias depending on one's past history, physical condition, social, and environmental factors and neuropathology.^{2,3}

The most stressful symptoms and signs, such as aggressive outbursts, difficult agitation, or psychosis, generally occur in more advanced stages, but may also be the first noticeable symptoms in neurocognitive disorders. Prominent behavioral abnormalities may also manifest as excessive impulsiveness or poor judgement in everyday life.⁴ Previous studies also suggest that some demented patients commit crimes.^{5,6} However, studies concerning criminal behavior in relation to developing dementia before the actual diagnosis is made are limited,⁷ and data of the timing of criminal behavior before diagnosis are nonexistent.

The aim of our register study was to explore whether the patients with subsequent diagnosis of Alzheimer's disease (AD), frontotemporal dementia (FTD), or Lewy body dementias (LBD, dementia with Lewy bodies and Parkinson's disease dementia) committed crimes in the four years preceding their diagnosis of neurocognitive disorder. Crime was defined as any type of offence against the Finnish legislation and recorded in the Finnish Police Register. The types of crimes committed were also explored and the frequencies of criminality citations were compared with those of the same-aged Finnish general population without neurocognitive disorders.

METHODS**Register Data***Information on diagnoses*

Data on patients with dementia diagnoses were obtained from the Finnish Hospital Discharge Register (FHDR).⁸ The FHDR contains information on both inpatient care in hospitals, local health center wards, or other hospitals (i.e., private, military, and prison hospitals) (HILMO), and primary health-care outpatient visits (AvoHILMO). In the HILMO, established in 1969, all diagnoses, including the main diagnoses and subdiagnoses of hospitalization at discharge, are subsumed in addition to basic characteristics such as age, gender, residence status, and general information on medication. The AvoHILMO covers all outpatient visits to publicly funded primary care since 2009.

Information on crime

Data on criminal offending were extracted from the Finnish Police Register, an electronic database holding data on all police contacts since the age of 15 years, the age of criminal responsibility in Finland. This register was established at the beginning of 1995, but it contains also data on criminal acts from previous years. A criminal act is recorded, if someone is suspected of any type of offence committed in Finland or occasionally abroad.^{9,10} In this study, only criminal offences classified as crimes were included, and minor delicts, such as making noise in a public area, were excluded. Access was granted to the FHDR by the Finnish Institute of Health and Welfare, and to the Finnish Police Register by the National Police Board. Information between the registers was linked by the unique identification number assigned to every Finnish citizen.

Study population

The study sample included 92 191 Finnish patients who had received a diagnosis of AD (N = 80,540, 53,028 women, 27,512 men), FTD (N = 1,060, 604 women, 456 men), or LBD (N = 10,591, 5,265 women, 5,326 men) between 1998 and 2015 and were aged 40 years or more at the moment of the initial dementia diagnosis. The classification of diagnoses in the FHDR was based on the 10th revision of the World Health Organization International Classification of Diseases (ICD-10) (WHO, 1992), which has been used in Finland since 1996. The study population included all cases with ICD -diagnoses of F00 and/or G30 codes in AD, F02.0 and/or G31.0 codes in FTD, F02.3 and/or G20 in Parkinson dementia, and F02.8 and/or G31.8 in dementia with Lewy bodies. Other types of dementia and central nervous system injuries were excluded. The first notification of the initial diagnosis and the type and number of criminal citations in each of the four years prior to the diagnosis of neurocognitive disorder were recorded.

Data Analysis

Data are presented as means with standard deviation and as counts with percentages. Statistical comparisons between groups were done using χ^2 and logistic regression models. Crude and standardized estimates of crime incidence or incidence rate ratios (IRRs) were calculated using Poisson regression models or random-effects negative binomial regression models (unstructured correlation structure), as appropriate. The assumptions of overdispersion in the Poisson model were tested using Lagrange multiplier test. A possible nonlinear relationship between crimes in the four years preceding diagnosis and age was assessed by using a four-knot -restricted cubic spline Poisson regression model. The ratio of observed to expected number of crimes, i.e., the SCR (number of actual crimes per number of expected crimes), was calculated using a subject-years methods, assuming a Poisson distribution. The numbers of observed cases and person-years at risk were counted in five-year age groups and separately for both genders and yearly. Probabilities of crimes in an age-, gender-, and event year-matched sample of the general population were calculated from data of the Finnish Police Register. The expected numbers of

subjects for all crimes combined were calculated by multiplying the number of person-years in each stratum by the corresponding average crime incidence in the whole population of Finland (Official Statistics of Finland). The statistical significance of the product terms was evaluated using a Wald test. Hommel's adjustment was applied where appropriate to correct levels of significance for multiple testing (post hoc). Stata 16.0 (StataCorp LP, College Station, TX) was used for the analysis.

Ethical Considerations

The study protocol was approved by the Ethics Committee of Helsinki University Central Hospital (no 186/13/03/00/16). Participants were not contacted and were not identifiable in the data, and thus, no informed consent was required.

RESULTS

The mean age at diagnosis was 81 years in the AD group, 71 years in the FTD group, and 73 years in the LBD group. Women represented 66%, 57%, and 50% of the study population, respectively. At least one crime was committed by 1.6% (95% confidence interval [CI] 1.5–1.7) of AD women and 12.8% (95% CI 12.4–13.2) of AD men, with the corresponding figures being 5.3% (95% CI 3.7–7.4), and 23.5% (95% CI 19.6–27.6) for FTD patients and, 3.0% (95% CI 2.5–3.5) and 11.8% (95% CI 10.9–12.7) for LBD patients (Table 1). The first crime was committed on average 2.7 (standard deviation 1.1) years before the diagnosis of neurocognitive disorders and the point of time did not differ between genders. Of the patients, most (5.7%) had only one offence contact, and 1.1% had two offence contacts.

The FTD group committed more crimes than the other two groups when calculated by 1000 person-years [Wald's test after adjusted (age, sex, and year at diagnosis) random-effects negative binomial regression model: $df=2$, $\chi^2=147.9$; $p<0.001$ (post hoc: FTD/AD; $p<0.001$ and FTD and/or LBD; $p<0.001$)] (Figure 1). The age- and sex-adjusted IRRs comparing the first and the fourth year results for all criminal offences per 1,000 person-years within the FTD group were 2.23 (95% CI 1.19–4.19) in women and 1.98 (95% CI 1.34–2.95) in men. In the AD group, IRRs

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TABLE 1. Crimes Per Patient in the Four Years Preceding Diagnosis

Crimes	AD	FTD	LBD	p Value	
				Crude [Multiple Comparison]	Age Adjusted [Multiple Comparison]
Men, Number	27 512	456	5326		
At least one crime	3 531 (12.8 %)	107 (23.5 %)	628 (11.8 %)	<0.001 ^a [AD/FTD, AD/LBD, FTD/LBD]	<0.001 ^b [AD/LBD, FTD/LBD]
1	2 455 (8.9 %)	63 (13.8 %)	408 (7.7 %)		
2	673 (2.4 %)	23 (5.0 %)	112 (2.1 %)		
3+	403 (1.5 %)	21 (4.6 %)	108 (2.0 %)		
Women, Number	53 028	604	5265		
At least one crime	835 (1.6 %)	32 (5.3 %)	156 (3.0 %)	<0.001 ^c [AD/FTD, AD/LBD, FTD/LBD]	<0.001 ^d [AD/LBD, FTD/LBD]
1	654 (1.2 %)	27 (4.5 %)	108 (2.0 %)		
2	126 (0.2 %)	3 (0.5 %)	31 (0.6 %)		
3+	55 (0.1 %)	2 (0.3 %)	17 (0.3 %)		

Notes: Hommel's multiple comparison (post hoc) procedure was used to correct significance levels for multiplicity (p <0.05). AD: Alzheimer's disease; FTD: frontotemporal dementia; LBD: Lewy body dementia.

^a Pearson's χ^2 : $df=2$, $\chi^2=51.3$.

^b Wald's test after age adjusted logistic regression models: $df=2$, $\chi^2=118.6$.

^c Pearson's χ^2 : $df=2$, $\chi^2=99.4$.

^d Wald's test after age adjusted logistic regression models: $df=2$, $\chi^2=19.3$.

FIGURE 1. Adjusted incidences of crimes in the four years preceding diagnosis of neurocognitive disorder. Dashed lines show the general Finnish population weighted to match the age and gender of the study population. Pyrs denotes follow-up person-years. p values indicated age and year at diagnosis adjusted statistical significances for linearity across time before diagnosis. p values were evaluated by using the Wald's test for linearity after adjusted random-effects negative binomial regression model. Models were adjusted for age and year at diagnosis: AD women: $df=1$, $\chi^2=2.3$; $p=0.13$. AD men: $df=1$, $\chi^2=0.1$; $p=0.75$. FTD women: $df=1$, $\chi^2=2.6$; $p=0.10$. FTD men: $df=1$, $\chi^2=14.5$; $p<0.001$. LBD women: $df=1$, $\chi^2=4.9$; $p=0.028$. LBD men: $df=1$, $\chi^2=12.0$; $p<0.001$. AD: Alzheimer's disease; FTD: frontotemporal dementia; LBD: Lewy body diseases; pyrs: person-years.

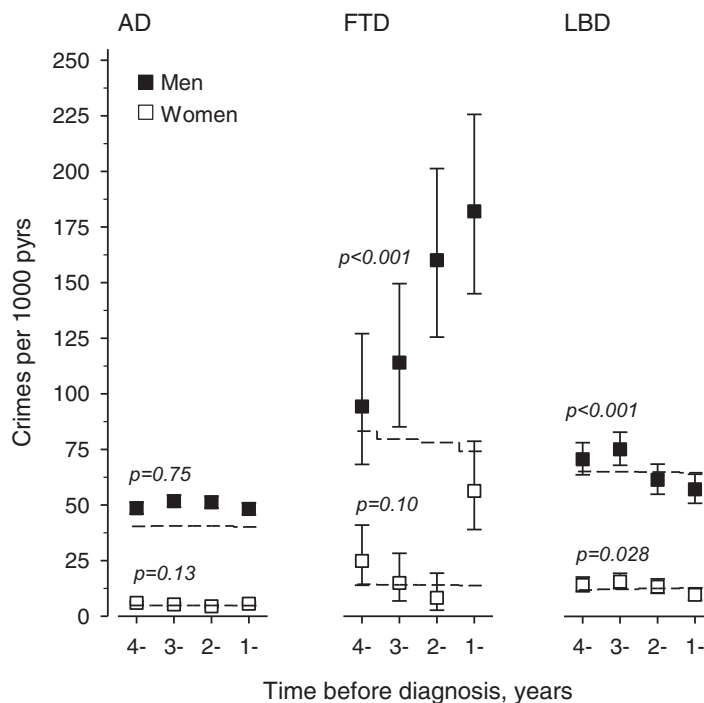
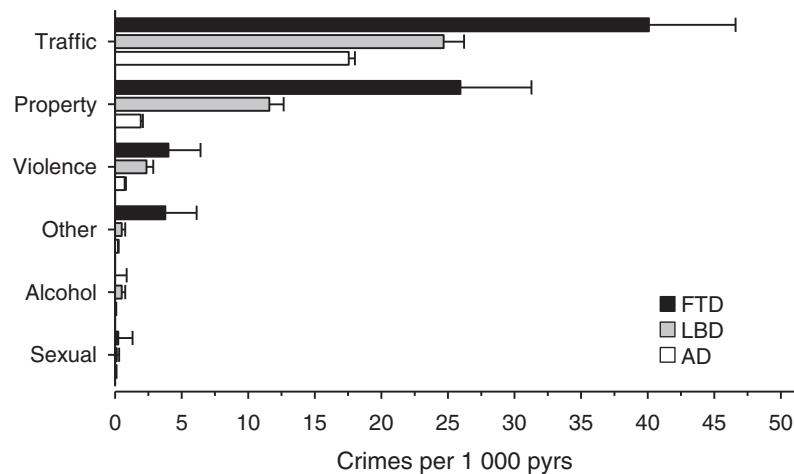


FIGURE 2. Types and incidences of crimes in the four years preceding diagnosis of neurocognitive disorders. Error bars represent 95% confidence intervals. Pyrs denotes follow-up person-years. FTD: frontotemporal dementia; LBD: Lewy body dementias; AD: Alzheimer's disease; pyrs: person-years.



were 0.93 (95% CI 0.79–1.09) in women, and 0.99 (95% CI 0.92–1.07) in men, and in the LBD group 0.69 (95% CI 0.48–0.99) in women and 0.80 (95% CI 0.68–0.94) in men. The linearity was strongest in FTD men (Wald's test for linearity after random-effects negative binomial regression model: $df=1$, $\chi^2=14.5$; $p < 0.001$). In the subgroups of LBD men (Wald's test for linearity after random-effects negative binomial regression model: $df=1$, $\chi^2=12.0$; $p < 0.001$) and LBD women (Wald's test for linearity after random-effects negative binomial regression model: $df=1$, $\chi^2=4.9$; $p=0.028$), the linearity was decreasing. Models were adjusted for age and year at diagnosis.

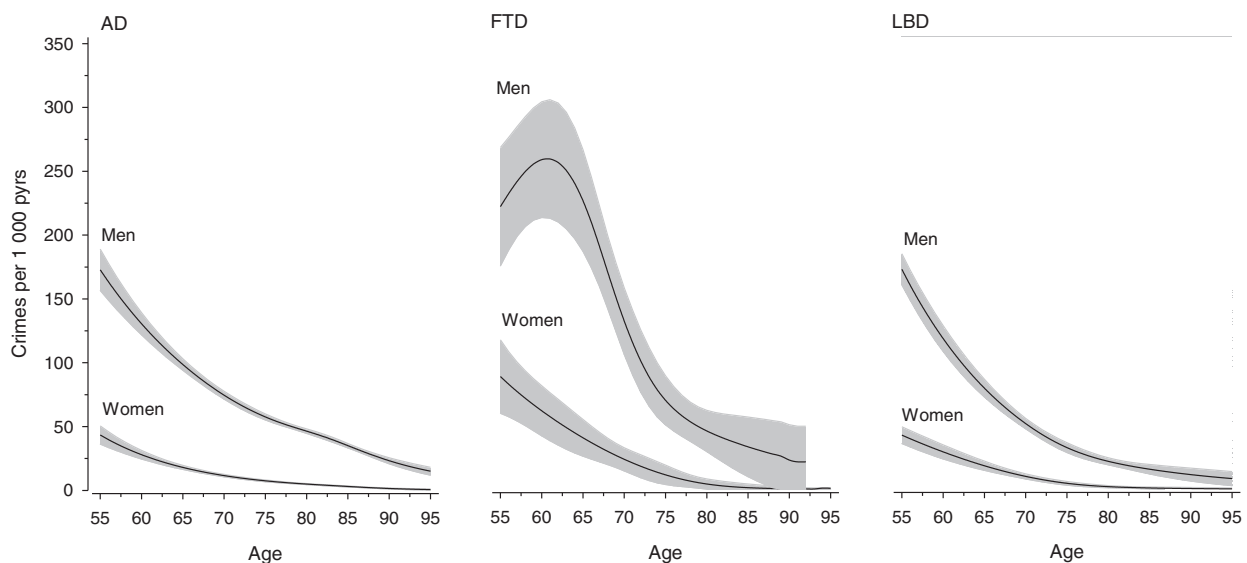
During the whole four-year period before the dementia diagnosis, the SCRs calculated by multiplying the number of person-years in each stratum by the corresponding average crime incidence in the whole population of Finland with the same age (Fig. 1) were 1.85 (95% CI 1.43–2.37, Pearson's χ^2 after Poisson model: $df=1$, $\chi^2=24.0$; $p < 0.001$) in FTD women and 1.75 (95% CI 1.54–1.98, Pearson's χ^2 after Poisson model: $df=1$, $\chi^2=79.5$; $p < 0.001$) in FTD men. In AD, they were 1.11 (95% CI 1.04–1.17, Pearson's χ^2 after Poisson model: $df=1$, $\chi^2=11.7$; $p < 0.001$) and 1.23 (95% CI 1.20–1.27, Pearson's χ^2 after Poisson model: $df=1$, $\chi^2=244.2$; $p < 0.001$), respectively. The

SCRs were not significant in the LBD group: 1.07 (95% CI 0.94–1.20, Pearson's χ^2 after Poisson model: $df=1$, $\chi^2=1.1$; $p=0.29$) in women and 1.02 (95% CI 0.96–1.07, Pearson's χ^2 after Poisson model: $df=1$, $\chi^2=0.4$; $p=0.51$) in men.

Traffic offences (FTD: 40.1 crimes per 1,000 person-years, LBD: 24.7, AD: 17.6) and crimes against property (FTD: 25.9, LBD: 11.6, AD: 1.9) were the two most common types of crime in every dementia category, and these crimes accounted for 94% of all criminal offences (Fig. 2). The two most common subtypes were traffic violations, such as speeding or endangering of traffic safety, in the former, and pilferages, or encroachments, such as trespassing, in the latter group of crimes. Violence, mainly assaults and illegal threats, was unusual (FTD: 4.0 crimes per 1000 person-years, LBD: 2.4, AD: 0.7). Serious crimes were extremely rare: one murder and one attempted murder, both of these occurring in the FTD group. The number of criminal acts decreased with age in every subgroup [Wald's test after restricted cubic spline Poisson regression model; $p < 0.001$ (AD women: $df=3$, $\chi^2=326.8$, AD men: $df=3$, $\chi^2=456.1$, FTD women: $df=3$, $\chi^2=20.0$, FTD men: $df=3$, $\chi^2=27.6$, LBD women: $df=3$, $\chi^2=173.4$, LBD men: $df=3$, $\chi^2=340.9$)] (Fig. 3).

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FIGURE 3. Crimes in the four years preceding diagnosis by age at onset. The curve was derived from a four-knot restricted cubic spline Poisson regression model. Shaded area represents 95% confidence interval. Pyrs denote follow-up person-years. AD: women: $df=3$, $\chi^2=326.8$; $p < 0.001$. AD men: $df=3$, $\chi^2=456.1$; $p < 0.001$. FTD women: $df=3$, $\chi^2=20.0$; $p < 0.001$. FTD men: $df=3$, $\chi^2=27.6$; $p < 0.001$. LBD women: $df=3$, $\chi^2=173.4$; $p < 0.001$. LBD men: $df=3$, $\chi^2=340.9$; $p < 0.001$. AD: Alzheimer's disease; FTD: fronto-temporal dementia; LBD: Lewy body dementias; pyrs: person-years.



DISCUSSION

To our knowledge, this is the first register study consisting of a large number of patients with different neurocognitive disorders having their criminal acts ascertained from the police register and committed before the diagnosis of neurocognitive disorder. This comprehensive data collection resulted in several novel findings regarding differences in the frequencies of criminal acts compared with the Finnish general population of the same age and in their timing before diagnosis. Firstly, during the four years preceding diagnosis, the incidence of crimes showed a substantially increasing trend in the male FTD group. In FTD females, the small number of individuals committing crimes obscures the significance. Secondly, the female and male criminality rates were higher in the AD and FTD groups than in the general population. Thirdly, the criminality in the LBD group did not differ from that of the general population, which is also noteworthy since no earlier studies concerning criminal behavior in this patient group were found.

In neurodegenerative disorders, behavioral, and psychological symptoms often precede memory problems or other cognitive symptoms.^{11–14} The FTD symptoms, especially behavioral variant FTD (bvFTD), may include increased impulsivity, aggression, disinhibition, decreased insight into own or other's behavior, and preservative compulsive behavior.^{4,13,15–17} Loss of empathy and sympathy can manifest already in very early stages of FTD, mainly due to degeneration of amygdalae.^{14,17,18} On the other hand, in AD, amnesia is typically the earliest sign of incipient dementia, together with mood disturbances, anxiety, apathy, or agitation, caused mainly by degeneration of hippocampal and posterior temporoparietal areas of the brain.¹⁹ In contrast to FTD, disinhibition and lack of empathy are not typical in the early stages of AD, and aggression occurs mainly in the later stages of dementia, especially in men.²

Around 80% of patients with Parkinson's disease will develop dementia, mostly after 20 years of illness.²⁰ Because the motor and functional disabilities and problems in the autonomic nervous system usually appear long before neurocognitive symptoms,

these patients are not always physically competent to commit crimes at the time of diagnosis. Parkinson's disease dementia and dementia with Lewy bodies are related conditions with variety in individual symptom profiles, but in the latter, neurocognitive problems are present within a year of the first motor signs.^{21–23} Although the majority of LBD patients suffer from behavioral and psychological symptoms, such as changes in personality, delusions, or visual hallucinations,^{24,25} they share a low risk of criminal behavior.

In frontal degeneration processes, antisocial behavior and social misconduct may present years before the diagnosis, while neurocognition and ability to function may remain relatively intact.^{13,26} Such a dementing process may result in early offending. In a previous Japanese study, male FTD patients with crimes were more seriously cognitively affected before the diagnosis of dementia than male FTD patients without any legal violations.⁶ In addition, women may have a shorter time from earliest symptoms to diagnosis than men because of more active help-seeking behavior.^{19,27,28} Thus, women may receive treatment and surveillance earlier, diminishing their risk for criminal behavior.

Patients in the FTD group were younger than AD patients. In our data, FTD patients were older than expected based on the literature.²⁹ Gil et al.¹⁶ found that diagnosis at higher ages is increasingly common and dependent on type of neuropathology. Especially FTD patients with Alzheimer's and vascular pathology have been older when diagnosed.^{16,30} Furthermore, in all diagnostic groups examined here, the older the patients were at diagnosis, the fewer crimes they had committed. This finding may be associated with physical retardation with aging, but also with longer time for achieving a diagnosis in younger patients than in older patients.¹⁹

In this study, 13% of FTD, 5% of AD, and 7% of LBD patients had committed at least one crime in the four years preceding diagnosis. The first contact with a police, when someone was suspected of a crime, took place on average 2.7 years before the diagnosis. Most of the patients were responsible for only one crime.

The more numerous offences in the FTD group were mostly explained by traffic offences and crimes against property. The findings are in line with the previous retrospective study of clinically diagnosed

dementia patients, in whom traffic violations were among the most frequent criminal acts in both bvFTD and AD groups.⁵ In the study of Liljgren et al., the total proportion of crimes reported to the police was 20% and 5%, respectively. Also in another study based on caregiver interviews, 52% of patients with bvFTD or semantic dementia (svPPA) showed criminal behavior, such as crimes against property or assaults, and only 12% of crimes were committed by AD patients.¹⁴ The only previous study concerning criminal behavior before diagnosis of dementia reported that 33% of bvFTD, 21% of svPPA, and 6% of AD patients (n = 412) had committed crimes.⁷ A major difference between earlier studies and ours is that earlier studies did not have police register data, which may affect the frequencies found.

In the present study, severe crimes, e.g., violent or sexual offences, were rare. In the literature, patients with dementia have been found in connection with sexual advances or violent attacks, but this phenomenon seems to be rare and more related to earlier personality problems.^{4,31,32} Psychosis as a prodromal symptom of dementia is probably more common than previously expected and may be a risk factor for serious aggression.³³ In bvFTD caused by a pathogenic expansion of the chromosome nine open reading frame 72, psychotic symptoms are more usual and serious than in other frontal degeneration processes.^{34,35,36} This form of FTD is overrepresented in Finland, and the diagnosis from the first psychiatric symptoms takes on average five years.^{34,35}

Study Strengths and Limitations

The main strength of this comprehensive epidemiological study is the nationwide databases of the FHDR and the Finnish Police Register, facilitating comparison between patients with neurocognitive disorders and the same-aged general population. The FHDR includes all patients diagnosed with FTD, AD, or LBD in Finland. The high quality of the FHDR has been demonstrated in a previous study.⁸ The Finnish Police Register provides a broad view of the different kinds of criminal behavior because it includes all reports directed to the police, not only those leading to convictions, resulting in high coverage. In addition, the criminal citations are retained permanently, not being expunged after some years. The Finnish Police Register also offered data for calculating probabilities

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of crimes in an age-, gender- and event year-matched sample of the general population.

Although high validity of the FHDR has been established, there is the possibility of an incorrect diagnosis because diagnoses were not confirmed by neuropathological examinations. The diagnoses were made according to the national clinical practice and diagnostic guidelines. Subtyping of FTD was not possible because our register study was based on ICD-10 diagnoses. The study was based on the FHDR and the Finnish Police Register notifications, and thus, we had no data on Mini Mental State Examination, education, social background, or level of income. There were no psychiatric diagnoses during the four-year period before the dementia diagnosis. The study concentrated on the four years preceding dementia diagnosis, and thus, we had no data on cognition during the study period. Since this is a register-based study, we were not able to examine any data on other life-long psychiatric, cardiometabolic, or central nervous system risk factors. The first Finnish Current Care Guidelines for AD were published in 2006 and an enlarged edition, including other dementias, came out in 2010.³⁷ It probably improved the diagnostics of neurocognitive disorders and resulted in earlier diagnosis, which may have influenced the number of patients and criminal acts recorded during the study.

CONCLUSION

In this register study of 92,121 patients with FTD, AD, or LBD, we found that behavioral symptoms leading to criminal acts may manifest years before the diagnosis of dementia. However, individuals committing crimes may also be evaluated more thoroughly, which may also affect the association between criminal acts and dementia diagnosis. The frequencies and time schedule differ between neurocognitive disorders, as especially patients with FTD are at increased risk for criminal behavior compared with the general population. While serious criminal acts are rare, the most usual offences, such as crimes against property

or traffic violations, place a burden on these patients and on society. If novel criminality occurs later in life, it may be associated with dementia, in which case diagnostics for neurocognitive disorders is warranted.

AUTHOR CONTRIBUTIONS

TT: Conception and design, interpretation, drafting, final approval, agreement to be accountable; MG: Conception and design, interpretation, drafting, final approval, agreement to be accountable; HKa: Conception and design, interpretation, acquisition, analysis, drafting, final approval, agreement to be accountable; RV: Conception and design, critical revising, final approval, agreement to be accountable; HE: Conception and design, critical revising, final approval, agreement to be accountable; TE: Conception and design, critical revising, final approval, agreement to be accountable; JS: Conception and design, critical revising, final approval, agreement to be accountable; NL: Conception and design, interpretation, critical revising, final approval, agreement to be accountable; HKo: Conception and design, interpretation, drafting, acquisition, final approval, agreement to be accountable.

DISCLOSURE

The authors report no conflicts with any product mentioned or concept discussed in this article.

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PREVIOUS PRESENTATIONS

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