Scandinavian Journal of Public Health, 1–8

ORIGINAL ARTICLE

Average lifespan variation among people with mental disorders in Denmark: a nationwide, register-based cohort study

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Abstract

Aims: Mortality associated with mental disorders has been estimated using metrics such as mortality rate ratios and life expectancy. However, the variation around the average life expectancy has never been quantified. The main aim of this study was to measure life disparity for people with mental disorders as a measure of inequality at the time of death. *Methods:* Using data from Danish registries, average life disparity was introduced and calculated to measure the lifespan variation associated with major types of mental disorders. Average life expectancy is also reported for completeness. *Results:* Compared with the general population, people with mental disorders not only had shorter average life expectancy, but experienced larger average life disparity. For those diagnosed with a mental disorder, average life expectancy increased between 1995 and 2021; however, average life disparity declined in women only, and did not change for men. In addition, the differences in both metrics between those with mental disorders and the general population were largest for substance use disorders and schizophrenia spectrum disorders. For these disorders, the differences even increased during the study period. *Conclusions:* **Mortality rates for individuals with mental disorders have been declining in recent decades in Denmark; however, the increase in the average life disparity emphasizes the increasing heterogeneity and inequality in lifespans within this group, which requires measures to promote a longer and more equal life for those with mental disorders.**

Keywords: *Mental disorders, average life expectancy, average life disparity, lifespan inequality*

Introduction

Globally, mental disorders are considered a serious public health concern. Mental disorders are one of the main causes of long-term disability and morbidity [1–3], and are associated with an increased risk of subsequent medical conditions [4,5]. People with mental disorders also experience higher mortality rates compared with the general population or those without mental disorders [6–8]. In addition to mortality rates and mortality rate ratios, excess mortality for people with mental disorders has also been reported as a reduction in life expectancy [9,10]. Life expectancy is a measure of mean mortality and indicates the average number of years a cohort of individuals would live if they were to experience the observed death rates in a given time period throughout their lives [11]. Previous studies estimated the gap in life expectancy between the general population and

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Date received 30 September 2023; reviewed 12 February 2024; accepted 4 March 2024

DOI: 10.1177/14034948241241554
journals.sagepub.com/home/sjp
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those with mental disorders to be around 15–20 years [9,10]. More recent studies considering the age-of-onset of the disorders have reported these estimates to be approximately 7 years for women and 10 years for men [6,11–14], but for some types of disorders, e.g., substance use disorders, the life expectancy gap can be up to 15 years [13].

Life expectancy is an informative metric. However, as an average measure, life expectancy does not reveal the underlying heterogeneity in individuals' ages at death [15,16]. Even though two populations might have similar life expectancy, they could experience notable differences in the distribution of ages at which individuals die [17]. Lifespan variation is important as it captures the most fundamental of all inequalities, namely, the inequality in length of life [18], and also has interpretations at different levels: at the individual level, it summarises the uncertainty in the timing of death, which will further affect decisions over the life course (e.g., retirement), whereas at the population level, it reflects the heterogeneity in underlying population health, and plays an important role in many areas such as the design of public health policies and the provision of medical care services [18–20]. In the field of demography, lifespan variation has been well documented as a complement for life expectancy-related research, and several indicators, such as life disparity, along with standard deviation and interquartile range, have been used to measure such variation [18]. However, none of these measures has been estimated in relation to mental disorders, which means that whether people with mental disorders face larger variation and uncertainty at the time of death remains unknown.

The main objective of this study was to estimate the variation in lifespan for people diagnosed with different types of mental disorders. Through a new measure, i.e., the average life disparity [21], we aimed to take into account the varying ages at diagnosis when measuring the variation in lifespan for those diagnosed. This is of crucial necessity as non-congenital diseases including mental disorders are usually not present at birth. With the use of high-quality Danish national registers, we compare the average life expectancy and average life disparity for those with mental disorders and the general population. In addition, we estimate potential changes in both metrics over time considering different periods between 1995 and 2021. In addition to the average life expectancy, analyses of the average life disparity present a complementary understanding of population health associated with mental disorders and draw the public's attention toward the health inequality among those diagnosed, thus contributing to the management of mental health-related policies.

Methods

Study population and identification of mental disorders

We designed a population-based cohort study including all 8,036,703 individuals living in Denmark at some point between 1 January 1995 and 31 December 2021. Information on births, immigrations, emigrations, and mortality was obtained from the Danish Civil Registration System [22,23]. We followed individuals from the latest of birth, immigration, or 1 January 1995 to the earliest of death, emigration, or 31 December 2021. Data on mental disorders were collected from the Danish Psychiatric Central Research Register [24], which contains data on all admissions to psychiatric inpatient facilities since 1969 and visits to outpatient and emergency departments since 1995. Based on the *International Classification of Diseases, Tenth Revision* (ICD-10), we identified individuals diagnosed with any mental disorder (ICD-10 codes F00-F99), and four specific types of disorders: substance use disorders (F10–F19), schizophrenia spectrum disorders (F20–F29), mood disorders (F30–F39) and neurotic disorders (F40–F48). For each individual in the study, the date of onset for each disorder was defined as the date of first contact (inpatient, outpatient or emergency visit).

Statistical analysis

Mortality rates for the general population and for people with any mental disorder as well as each specific type of mental disorder were calculated as the number of deaths divided by the total follow-up time in person-years. Age-specific mortality rates (in 1-year intervals) were further used to construct sex-specific life tables for the general population, people with any mental disorder and those diagnosed with different types of mental disorders over the whole study period (1995–2021) and five specific periods (1995–2000, 2001–2005, 2006–2010, 2011–2015, 2016–2021). The maximum age was set to 110 years for this study. We first looked at the distributions of age-at-death for those with mental disorders and the general population who were alive at the age of 15 years. However, as not all mental disorders are diagnosed at or before that age, we calculated the average life expectancy following the method described by Andersen and colleagues [6,12], for which a tutorial and R package are available [11]. With this method, the variation in ages of onset of mental disorders was incorporated in the estimates, and the life expectancy at each possible age of diagnosis for those with mental disorders and the general population was

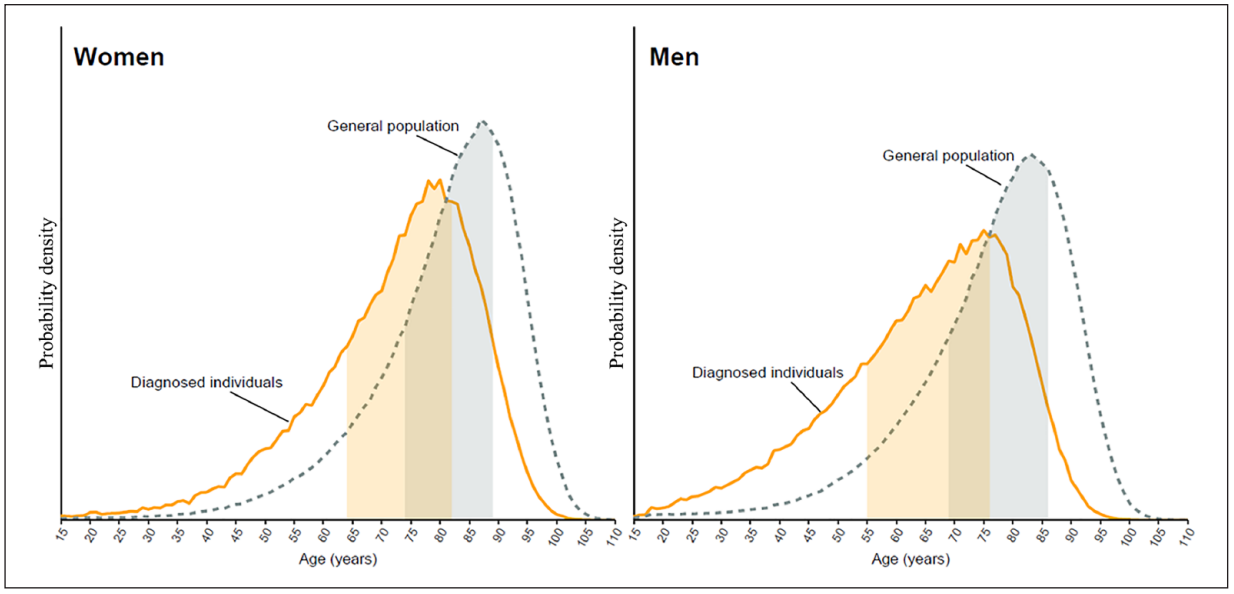

Figure 1. Age-at-death distributions after age 15 years for individuals diagnosed with any mental disorder (yellow) and the general population (grey), separately for women and men. The interquartile ranges of age-at-death (25%–75%) are highlighted in shaded areas.

estimated. These age-specific estimates were then averaged weighted by the corresponding number of incident cases of mental disorders at that age for both the diagnosed and the general population.

The variation in lifespan for those with mental disorders (and specific types of disorders) and the general population was estimated using the average life disparity after diagnosis [21], which was calculated in a similar approach as the average life expectancy and can be defined as follows:

$$\overline{e^{\dagger}} = \frac{\sum_{x=m}^{M} w(x).e^{\dagger}(x)}{n},$$

where $e^{\dagger}(x)$ denotes the life disparity at each possible age of onset x, which ranges from the minimum onset age m to the maximum onset age M. It was then weighted by the corresponding number of cases diagnosed with mental disorders at that age, $w(x)$, and divided by n, the total number of cases. In our study, this new metric was built on life disparity $e^{\dagger}$, which was defined by Vaupel and Canudas-Romo [25] and is a measure of average remaining life expectancy at time of death [20]. As one of the most commonly used indicators for measuring variation in lifespan, it is acknowledged for its intuitive public health interpretation and additive mathematical properties [16,26]. More importantly, it is related strongly to other dispersion metrics, which means that estimates based on this indicator are robust [27].

All analyses were done in R version 4.2.1 in the secured server of Statistics Denmark. This study was registered with the Danish Data Protection Agency at Aarhus University (record no. 2016-051-000001-2587) and was approved by Statistics Denmark and the Danish Health Data Authority. In Denmark, no ethical approval is required for register-based research.

Results

Between 1995 and 2021, 4,016,256 women and 4,020,447 men were followed up for 144,775,261 person-years. A total of 952,297 individuals (11.8%) were diagnosed with a mental disorder (514,599 (12.8%) women and 437,698 (10.9%) men). During the follow-up period, 1,491,443 individuals (16.4%) died (755,408 (18.8%) women and 736,035 (18.3%) men). Among those diagnosed with a mental disorder, 282,698 (29.7%) individuals died (155,672 (30.3%) women and 127,026 (29.0%) men).

Figure 1 presents the age-at-death distributions for individuals diagnosed with mental disorders and the general Danish population restricted to those alive at age 15 years by sex over the period 1995–2021. Compared with the general population, the distribution of deaths was shifted towards younger ages for both men and women with mental disorders. For women, the interquartile range of age-at-death occurred during a 15-year period between ages 74 years and 89 years, whereas for women with mental disorders, the interquartile range of age-at-death was observed between ages 64 years and 82 years (an 18-year period), representing not only a younger age

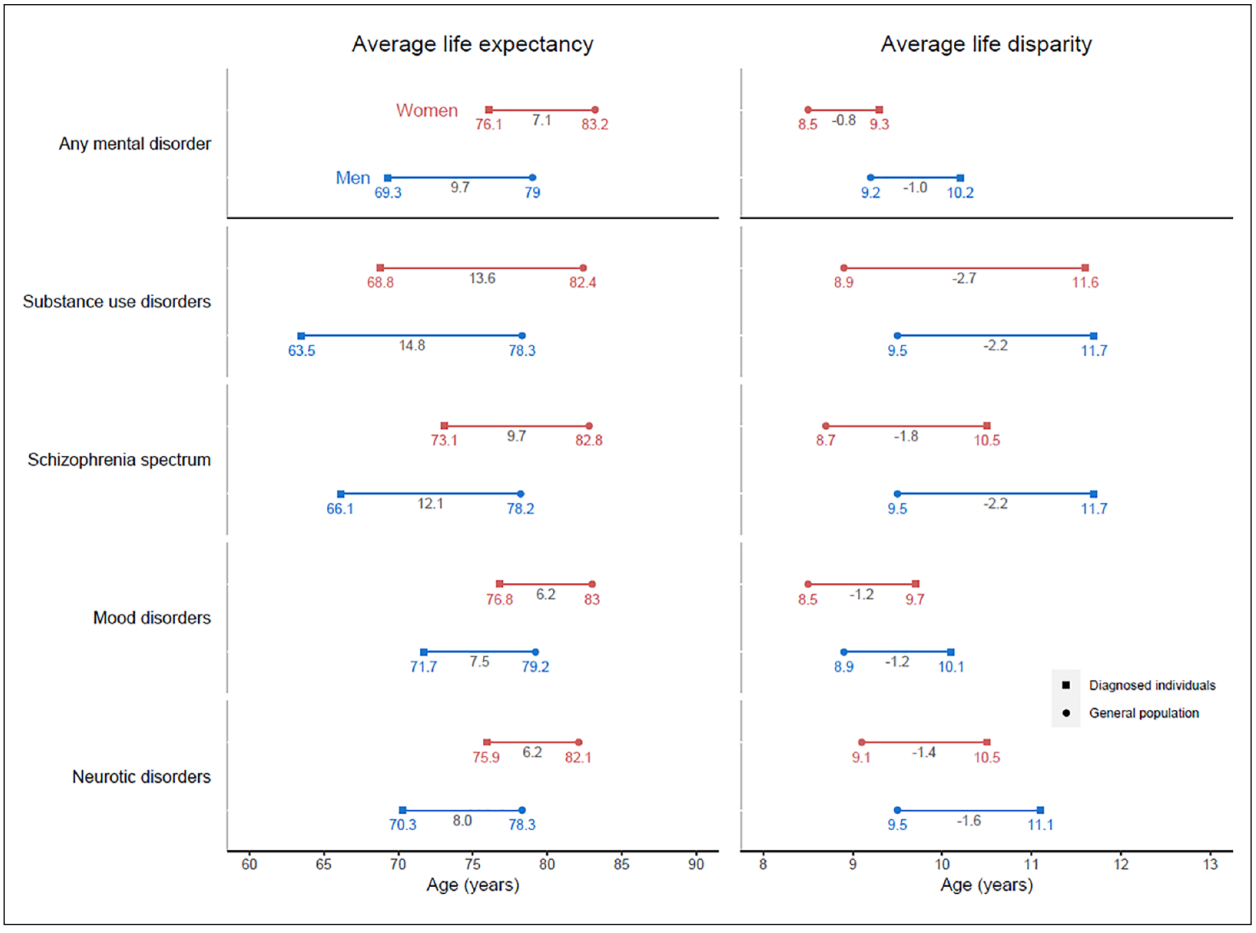

Figure 2. Average life expectancy and average life disparity for individuals diagnosed with mental disorders and the general population, separately for women and men. Results for the general population are different for each type of mental disorder because they are matched on the age of those diagnosed with each mental disorder.

but also a larger variability in the age at death. Similar patterns of age-at-death distribution differences could be found for men and for those diagnosed with specific types of mental disorders, as shown in Figure S1.

Figure 2 shows the average life expectancy and average life disparity (after disease diagnosis) for individuals diagnosed with different types of mental disorders and the general population. People diagnosed with any mental disorder had a lower average life expectancy than the general population (difference of 7.1 years for women and 9.7 years for men). In addition, those with a diagnosed mental disorder also experienced larger variation at the age of death. The average life disparity for people with any mental disorder was 9.3 years for women and 10.2 years for men, which was 0.8 and 1.0 years more than women and men from the general population. This pattern was observed for both sexes and for specific types of mental disorders. Substance use disorders were associated with the largest gaps in both average life expectancy (13.6 years for women and 14.8 years for men) and average life disparity (2.7 years for women and 2.2 years for men), compared with the general population.

Changes in the average life expectancy and average life disparity for those diagnosed with a mental disorder and the general population for different time periods are shown in Figure 3 and Supplemental Table S1. During the study period, there were continuous increases in the average life expectancy for both sexes and for those diagnosed with a mental disorder as well as the general population. For people diagnosed with a mental disorder, the average life expectancy increased from 73.7 years to 77.3 years for women and from 66.3 years to 71.3 years for men between 1995–2000 and 2016–2021. For women and men in the general population, the average life expectancy increased from 81.5 to 84.2 years and from 76.9 years to 80.5 years, respectively. Thus, the gap between the two groups was reduced from 7.8 to 6.9 years for women and from 10.6 to 9.2 years for men. Regarding the average life

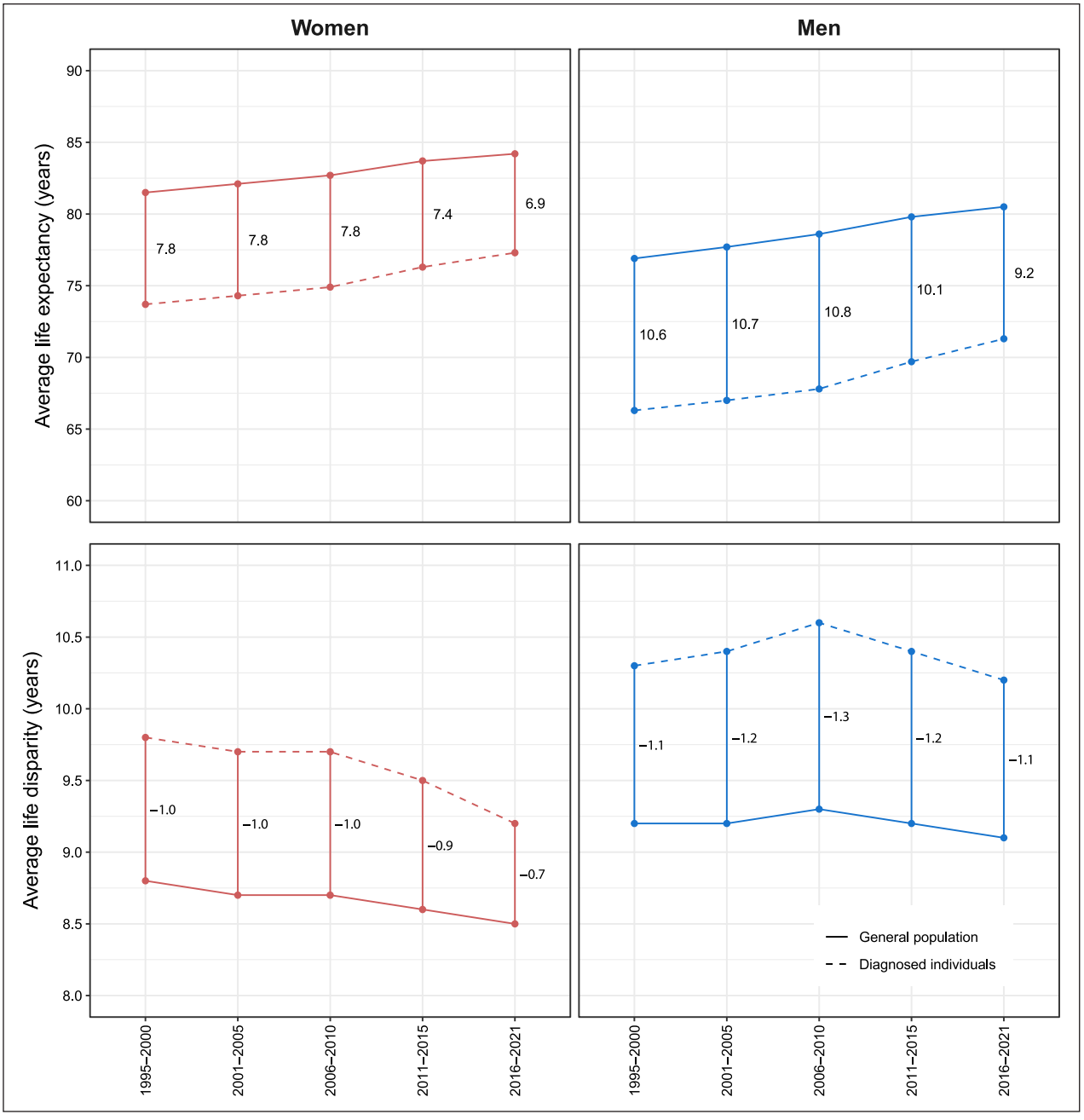

Figure 3. Time trends in average life expectancy and average life disparity for those diagnosed with a mental disorder and the general population of same age and sex. All estimates are available in Supplemental Table S1.

disparity, an overall declining trend could be seen only among women with mental disorders and women from the general population, with the gap between the two groups declining from 1.0 to 0.7 years during the period 1995–2000 to 2016–2021. However, for men, the average life disparity increased from 1995–2000 to 2006–2010 (10.3 years to 10.6 years for those diagnosed with mental disorders and 9.2 years to 9.3 years for the general population), and decreased thereafter. Nevertheless, the gap remained constant at around 1.1 years between 1995–2000 and 2016–2021.

Time trends for specific types of mental disorders are shown in Supplemental Table S1 and Supplemental Figures S2 and S3. During the study period, people with different types of mental disorders generally followed similar increasing trends in average life expectancy as people with any mental disorder. However, the life expectancy gap for those with substance use disorders and schizophrenia

spectrum disorders compared with the general population widened over time. Despite the fluctuations, for some disorders, such as mood and neurotic disorders, the average life disparity was reduced for both women and men. This declining trend was not found among people diagnosed with substance use disorders and schizophrenia spectrum disorders. For these two types of disorders, the average life disparity gap widened from 1995 to 2021. As these metrics are averaged over the age-of-onset distribution, they have to be interpreted considering the steadily declining trend in the age of diagnosis that we observed during the study period for all types of mental disorders (Supplemental Figure S4).

Discussion

In this study, we estimate for the first time average life disparity (alongside average life expectancy) for individuals diagnosed with major types of mental disorders for both sexes and across periods, thus providing a broader picture of population health associated with mental disorders. On average, individuals diagnosed with a mental disorder experienced not only shorter average life expectancy, but also greater average life disparity, which means that there is a larger inequality in length of life among those diagnosed with mental disorders. Furthermore, while the gap in the average life expectancy and average life disparity decreased over time for those diagnosed with mood and neurotic disorders compared with the general population, we observed opposite trends for those diagnosed with substance use disorders and schizophrenia spectrum disorders.

Our study is in line with previous studies on average life expectancy based on Danish registers [6,13,14,28], but we included data updated to the year 2021, and found a continuous increase in average life expectancy between 1995 and 2021 among people having any diagnosed mental disorder, including the period after the COVID-19 outbreak and subsequent social restrictions. Meanwhile, for people with mental disorders, we found an overall declining trend in the average life disparity, although the reduction was accompanied by fluctuations among men over the study period. Typically, average lifespan variation decreases with increases in average life expectancy, which is explained by a reduction in mortality rates over time [28]. However, our finding of inverted U-shape in average life disparity for men with mental disorders requires further investigation. In Denmark and other countries, there has been a trend toward diagnosing more people with mental disorders, and diagnosing them at younger ages [29], and there has been an increase in mental health symptoms, especially among young people [30]. Thus, it is necessary to understand whether the group of individuals with mental disorders has changed over time, which could lead to a more heterogeneous group of individuals and, consequently, a larger life disparity in some periods. In addition, it is also necessary to estimate whether improvements in treatment for individuals with mental disorders are beneficial only for a subgroup of individuals, which would explain the increases in life disparity during some periods and, thus, inequalities within this group.

In this study, we further examined the changes in average life expectancy and average life disparity for major types of mental disorders. Consistent with previous research based on Danish register data [28], we found that the average life expectancy gap was reduced between those with mood disorders and neurotic disorders and the general population during the study period. Regarding the average life disparity, a declining gap could also be observed among people with these two types of disorders. However, for people with substance use disorders and schizophrenia spectrum disorders, the average life disparity gaps with the general population were relatively larger, and widened further between 1995 and 2021. This may be attributable to the higher mortality rate among people diagnosed with substance use disorders and schizophrenia [13], and the greater proportions of age distribution at diagnosis for these conditions, which concentrate mainly at younger age groups, compared with other types of mental disorders [29].

To the best of our knowledge, the average life disparity for individuals with mental disorders has not been estimated before. It needs to be noted that this metric cannot be simply interpreted as life disparity at birth, as these individuals have survived until the diagnosis of a mental disorder. Similar to the average life expectancy [6,13,14], the average life disparity avoids the assumption that diagnosed individuals experience age-specific mortality rates of the diagnosed throughout their entire lives and considers the underlying age of onset distribution. The use of this metric is important as it provides a more detailed way to investigate the distribution of lifespans among people with a given disease, namely, a mental disorder, rather than merely focusing on their average length of life. Besides, it allows deeper investigations of related outcomes in the future, including risk factors associated with being at the extremes of the distribution.

Greater average lifespan disparity, together with lower average life expectancy, underlines the health disadvantage among people diagnosed with a mental disorder. The larger variation in lifespan for individuals with a diagnosis indicates that this group should

be treated as a heterogeneous group. This is due not only to the different impact on health outcomes across types of mental disorders and sexes, but also to the potential influence of underlying factors, e.g., socioeconomic position. Previous research has found that lifespan variation varies across social groups, with people having lower socioeconomic position experiencing shorter life expectancy and larger variation in age-at-death than those having higher socioeconomic position [31–33]. Among people diagnosed with mental disorders, less-advantaged individuals including those with lower level of income or education attainment may also die at earlier ages. Given the high correlation between socioeconomic position and poor mental health, it is necessary to study the interplay between these factors in future studies. In addition, we considered four major groups of mental disorders when investigating specific subtypes. Similar analyses for people diagnosed with more specific types of disorders (e.g., bipolar disorder or major depressive disorder) would be useful to evaluate the characteristics of individuals with mental disorders in greater detail.

The main strength of our study is that we included the entire population based on data from administrative registers; thus, selection bias is unlikely. Although these nationwide registers provide valuable information for epidemiological research [23], some limitations should be acknowledged. First, individuals with mental disorders were diagnosed in psychiatric units through the hospital system. While most cases with severe disorders like bipolar disorder or schizophrenia might be identified, it is likely that individuals suffering from milder conditions like depression or anxiety would not be identified through this register [34]. Moreover, there might be a possibility of misclassification of individuals diagnosed with a wrong diagnosis; however, validation studies have shown the Danish hospital registers to be accurate [35,36]. In addition, our study answers questions on the distribution of lifespan. Whether these years are lived in good or poor condition is unknown. Finally, as information on some modifiers (e.g., sleep) is not included in administrative data, this study is unable to evaluate this impact on their potential influences.

The use of the average life expectancy and life years lost method in current epidemiological studies has provided a more accurate way to evaluate the remaining life expectancy among people with a mental disorder. However, it is incomplete if focussing only on average life expectancy. An additional evaluation of average life disparity provides a more comprehensive understanding of the effect of mental disorders on mortality. Over the past decades, there have been reductions in mortality rates among people with mental disorders; however, the gaps in average life expectancy and average life disparity remained substantial, and have even widened for particular types of disorders when compared with the general population. This finding revealed the lifespan inequality among people having a diagnosis of a mental disorder, and also drew attention towards other factors, e.g., the distribution of age at diagnosis towards a younger population or an increasing heterogeneity within those diagnosed with a mental disorder that could balance potential improvements in reducing inequalities within this group. The combination of average life expectancy and average life disparity highlights the importance of developing policies to make lifespan for people with mental disorders on average longer while making it more equal.

Data availability

The individual-level data used for this study are not publicly available but can be obtained by application to Statistics Denmark and the Danish Health Data Authority.

Declaration of conflicting interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: this work was supported by a Lundbeck Foundation Fellowship to OP-R (R345-2020-1588). OP-R has also received funding from Independent Research Fund Denmark (grants 1030-00085B and 2066-00009B). The funders of the study had no role in developing the methodology, study design, data collection, data analysis, data interpretation, or writing of the report.

Ethics Approval

This study was registered with the Danish Data Protection Agency at Aarhus University (record no. 2016-051-000001-2587) and was approved by Statistics Denmark and the Danish Health Data Authority. In Denmark, no ethical approval or informed consent is required for register-based research. All data was anonymised and specific individuals could not be identified.

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Supplemental material

Supplemental material for this article is available online.

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