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Economics of mental wellbeing: A prospective study estimating associated productivity costs due to sickness absence from the workplace in Denmark

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A R T I C L E I N F O

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A B S T R A C T

Background: Few studies have assessed associations between mental wellbeing (MWB) and productivity loss using nationally-representative longitudinal data. The objective of the study was to determine how different levels of MWB are associated with future productivity loss or costs due to sickness absence.
Methods: Data stem from a Danish nationally representative panel study of 1,959 employed adults (aged 16–64 years old) conducted in 2019 and 2020, which was linked to Danish register data. The validated Short Warwick-Edinburgh Mental Wellbeing Scale (SWEMWBS) was used to assess MWB in 2019. The outcome was days absent from work due to sickness in 2020. Linear regression models were used to predict sickness absence in 2020 while adjusting for sickness absence in 2019, sociodemographics and health status, including psychiatric morbidity. Productivity loss or costs were estimated using the human capital approach (HCA) and friction cost approach (FCA). Costs are expressed in USD PPP.
Results: Each point increase in MWB was significantly associated with fewer sick days in 2020 and, by extension, lower productivity loss (reported in the order HCA/FCA). As compared to low MWB, moderate MWB was associated with $-1,614/$-1,271 per person in 2020, while high MWB was associated with $-2,351/$-1,779 per person in 2020. Extrapolated to the Danish population (2.7 M employed adults aged 16–64) and as compared to low MWB (12.3% of the population), moderate MWB (67.3% of the population) was associated with lower productivity loss amounting to $-2.9bn/$-2.3bn in 2020, while high MWB (20.4% of the population) was associated with lower productivity loss amounting to $-1.3bn/$-0.9bn in 2020.
Conclusions: Higher levels of MWB are associated with considerably less productivity loss. Substantial reductions in productivity loss could potentially be achieved by promoting higher levels of MWB in the population workforce.

1. Introduction

The economic costs of mental health problems are significant. The total costs related to mental health problems in Europe have been estimated at more than 4% of its GDP, or over €600 billion, across the 28 EU countries in 2015 (OECD/EU, 2018). In all, 1.3% is accounted for by direct spending on health care, while 1.2% is accounted for by spending on social welfare programmes. However, the greatest impact (1.6%) relates to productivity loss from paid employment. Other reports have estimated the total cost of mental health problems to employers across

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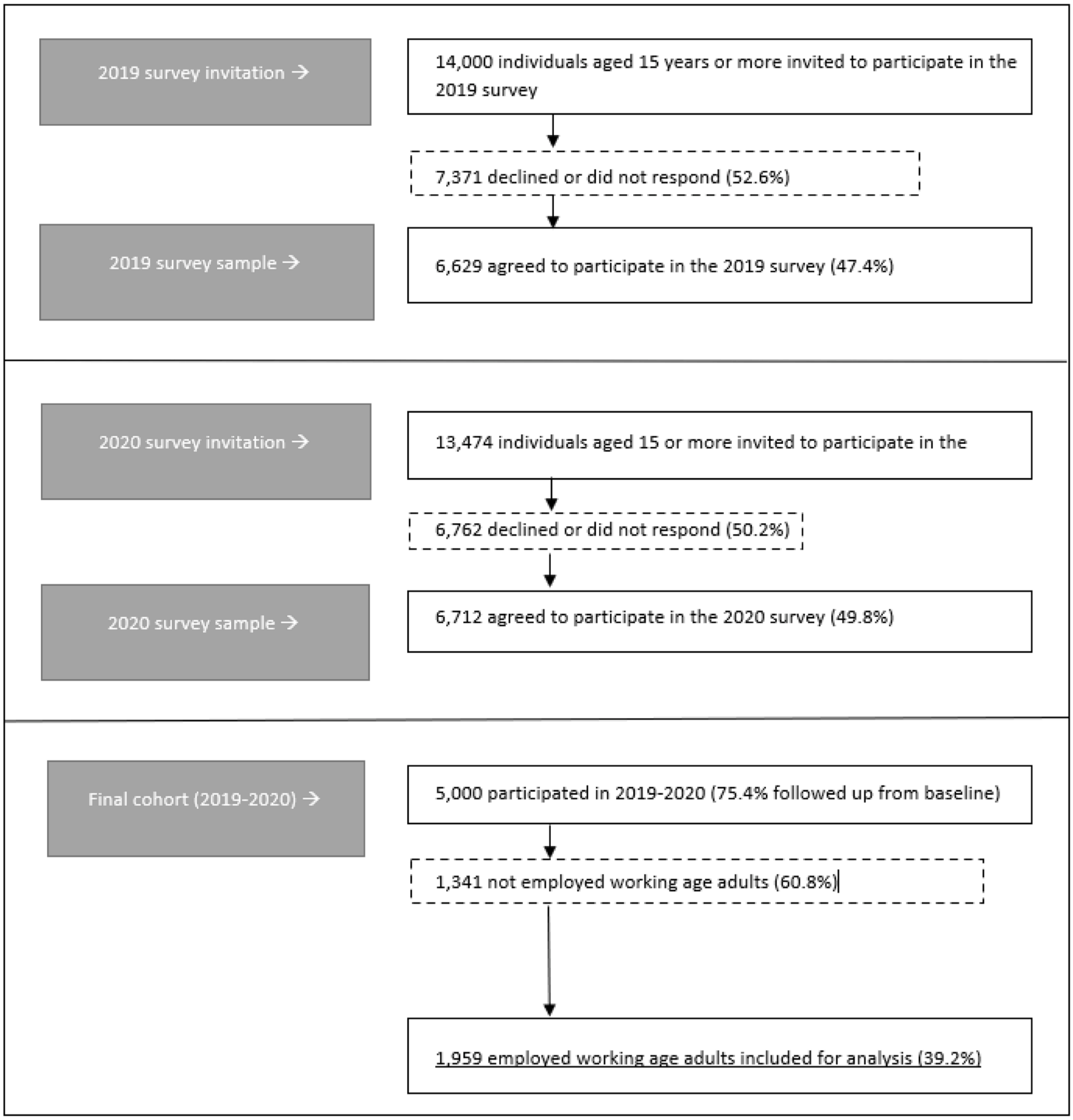

Fig. 1. Flowchart of the study sample.

Europe to be between €378-€469 billion per year (Sinclair & Sinclair, 2021). These costs however only reflect part of the impact as they relate mainly to negatively framed measures and the presence of psychopathological symptoms (e.g., depression scales) or mental disorder diagnoses. Mental health should be also assessed with positively framed measures, i.e., wellbeing scales to ensure that the full costs of mental health problems are uncovered.

The concept of mental wellbeing (MWB) was developed in the context of positive psychology (Jahoda, 1959), and various studies have shown that the presence of positive mental health is more than simply the absence of mental illness (Huppert & Whittington, 2003; Keyes, 2015; Shah et al., 2021). MWB measures have been developed to enable the monitoring of MWB and the evaluation of interventions, programmes and approaches to promote mental health. The concept of MWB has proven to be of interest in both the emerging discipline of public mental health (Regan et al., 2016), as well for mental health services and primary care, where it has been linked to patient-centered care and recovery agendas (Farnier et al., 2021; Shah et al., 2021; Trousselard et al., 2016). While the issue of the substantial costs related to mental illness has gained increasing recognition over the past 30 years (Knapp & Wong, 2020), there is a lack of comprehensive longitudinal population-based studies documenting how different levels of MWB also influence productivity costs on a national level.

According to a number of reviews (De Neve et al., 2013; Diener & Chan, 2011; Diener et al., 2017; Lyubomirsky et al., 2005; Walsh et al., 2018), wellbeing is associated with better physical and mental health status, longevity, health behaviours, as well as enhanced resilience and recovery from illness, all of which may prevent sickness absence from the workplace. Further, reviews (De Neve et al., 2013; Isham et al., 2021, 2019; Krekel et al., 2019) have shown that higher levels of wellbeing are beneficial in terms of productivity, resilience and motivation to remain active on the labor market, all of which may have implications for sickness absence from the workplace. However, most of these studies have focused on evaluative (e.g., life satisfaction) or hedonic wellbeing (i.e., feeling good), but not on more comprehensive MWB measures that include both functioning as well as positive emotions. Recently, we conducted a study using Danish population-based register data, in which we showed that a continuous measure for MWB (WEMWBS) in 2016 was inversely associated with healthcare costs in 2017 (Santini et al., 2021a). The present study extends this previous work by estimating the potential reductions in productivity losses or costs associated with higher levels of MWB.

Few studies have assessed associations between MWB and productivity loss using nationally-representative longitudinal data. Moreover, to the best of our knowledge, no studies to date have reported an analysis using combined survey and register-data, and extrapolated results in order to estimate associated productivity loss for an entire country. A research gap currently exists in terms of the potential return on investment that might be gained from successfully implementing programmes and policies to promote MWB (EU, 2019; Forsman et al., 2015; WHO 2005). In this study, using a large random sample of the adult Danish population, we set out to investigate to what extent different levels of MWB are associated with future productivity loss due to sickness absence. Regarding terminology, the terms 'productivity loss' and 'productivity cost' are used interchangeably. To estimate productivity loss, two economic approaches were used, the Human Capital Approach (HCA) and the Friction Cost Approach). Under the HCA, lost productivity is estimated by valuing lost work time at the market wage for the entire period a worker is absent. The FCA is similar, with the main difference being that only the 'friction' period (the time it takes to replace a worker) is considered productivity loss. Based on the aforementioned evidence, we hypothesised that (1) each point increase in MWB scores (using a continuous measure) would, in the next year, be associated with reduced sick days from the workplace and, by extension, productivity loss, and (2) higher levels of MWB (using a categorical measure) would be associated with incrementally reduced loss due to sickness absence as compared to low MWB.

2. Methods

2.1. Sampling

The Danish Health and Wellbeing Survey (Rosendahl Jensen et al., 2021) is the Danish part of the European Health Interview Survey (EHIS). Everyone with residence in Denmark has a personal identification number which is used throughout administrative registers and stored in the Civil Registration System (Pedersen, 2011; Thygesen et al., 2011). From the Civil Registration System, 14,000 individuals aged 15 years or more were randomly selected and invited to complete a self-administered questionnaire (paper or web-based) in 2019 (data collected between 5 September and December 31, 2019). In total, 6629 individuals (47.4%) completed the questionnaire. Subsequently, all individuals from the 2019 survey, who were still alive and living in Denmark in mid-August 2020, were invited to participate in a follow-up survey (data collection between 4 September and November 8, 2020). 13,474 eligible individuals were invited to the follow-up survey in 2020. In all, 6712 individuals completed the self-administered questionnaire in 2020, out of which 5000 had also completed the questionnaire in 2019 (resulting in 75.4% participating in the follow-up survey).

For this analysis, the sample (of 5000 individuals) was restricted to include only individuals aged 16–64 years old (minimum working age up to the standard retirement age) (Freudenberg et al., 2018) that were also employed, resulting in a final sample of 1959 individuals (Fig. 1 illustrates a flowchart of the study sample). The survey data were linked at an individual level to registers at Statistics Denmark, which allows for the merging of data on the amount of sickness absence from the workplace and health status, among other variables. The study design and the data collection methods have been described in detail elsewhere (Rosendahl Jensen et al., 2021). All data were pseudonymised, to hinder the possibility of tracing back to specific participants. The study complies with the Helsinki 2 Declaration on Ethics and is registered with the Danish Data Protection Authority. The study was also approved by the University of Southern Denmark (SDU) Research and Innovation organisation (RIO) (ID 11.107). SDU RIO examines and approves all scientific and statistical projects at SDU according to the Danish Data Protection Regulation.

2.2. Outcome: number of sick days within 2020

In Denmark, sickness absence up to 30 work days per year is covered by the employer, while sickness absence of 31 or more work days is compensated by the government (i.e., Danish registers only record sickness absence of more than 30 days). While self-reported information pertaining to sick days is subject to recall bias, register data does not have this limitation, and is therefore generally considered to be more reliable (Thorsen et al., 2018). Previous research from Denmark has demonstrated satisfactory agreement between self-reported sickness absence and register-based sickness absence (Stapelfeldt et al., 2012; Thorsen et al., 2018). In the present data, in terms of reporting over or under 31 sick days, there was 91.7% agreement between self-reported sick days and register-based sick days (i.e., 8.3% of self-report did not correspond with register-based sick days). When restricting to those reporting 31 or more sick days, 88.3% of self-report was in agreement with register-based sick days. In this study, we needed the self-report measure for sickness absences of 30 days or less. For this reason, we used both survey and register data (i.e., the 2020 follow-up survey and register-data post 2019 for the outcome variable) to construct one combined variable for number of sick days (sickness absence from work regardless of whether this work took place on weekdays or during weekends) within 2020. First, data on sickness absence of 0–30 days in 2020 were extracted from the survey. Employed respondents were presented with the items "Have you within the past 12 months been absent from work due to sickness, injuries or other health problems?", with response options "yes" or "no"; and "How many days in total within the past 12 months have you been absent from work due to sickness, injuries or other health problems?", with respondents having the opportunity to respond with a number. Responses of 1–30 days were coded for those responding a maximum of 30 days to the latter item, and respondents answering "no" to the first item was coded as 0 (i.e., creating a variable that ranged from 0 to 30).

Next, data on sickness absence of 31 days or more in 2020 were extracted from the Danish Register for the Evaluation of marginalisation (DREAM) (Hjollund et al., 2007). The following DREAM codes were used: 774 (sick leave from flex-jobs, i.e., contracts with more flexible conditions for citizens with reduced capacity to work due some form of disability), 890, 892, 893, 894, 895, 896, 897, 898, and 899 (all sick leave codes for either ordinary employment, various job training programs or apprenticeships) (Hansen et al., 2015). Sickness absence in DREAM is composed of number of weeks of sickness absence (i.e., corresponding to five days of work), and a variable was then created that consisted of intervals of five days. In other words, a DREAM value of 1 (i.e., one week exceeding the 30-day threshold) was coded as 35 sick days, a value of 2 was coded as 40 sick days, and so on, and continuing up until the end of the year (regardless of vacation days as this does not interfere with sick leave status). Since each week may represent between 1 and 5 sick days, every final week recorded with sickness absence was given the middle value (i.e., 2.5). Finally, the two variables were combined into one continuous variable to represent the number of sick days within 2020 (if there was a conflict between the survey data and the register data, the register-data took precedence in our coding). Two economic approaches, the Human Capital Approach (HCA) and the Friction Cost Approach (FCA), were considered in the coding of the outcome variables (see section on Statistical analysis and economic approach for more information on these two approaches). Because the DREAM data records sickness absence of 31+ absence days throughout the entire calendar year, the combination of the two variables made it possible to have more sickness absence than what is possible within a year. Since the year 2020 had 254 working days (regardless of vacation days as these are generally paid vacation days according to Danish legislation), the variable was coded with a maximum value corresponding to this number (i.e., values above this number were recoded as 254), resulting in the final HCA outcome variable ranging from 0 to 254. For the FCA analysis, the maximum value of absence days was set to 90, resulting in a final FCA outcome variable ranging from 0 to 90. Similar approaches were used to construct variables for sick days within 2019 (used for adjustment in HCA and FCA models).

2.3. Exposure: mental wellbeing (MWB)

This study used the Short Warwick-Edinburgh Mental Wellbeing Scale (SWEMWBS), which is a 7-item MWB scale that has been validated in Denmark (Koushede et al., 2019) and used for the baseline survey (2019). SWEMWBS consists of seven positively worded questions pertaining to MWB experienced within the past 14 days: (1) I've been feeling optimistic about the future, (2) I've been feeling useful, (3) I've been feeling relaxed, (4) I've been dealing with problems well, (5) I've been thinking clearly, (6) I've been feeling close to other people, and (7) I've been able to make up my own mind about things. Response options were: none of the time 1; rarely 2; some of the time 3; often 4; all of the time 5. Summing item scores leads to a score between 7 and 35; the higher the score, the higher MWB. The final scores are then commonly transformed to a metric score to enhance scaling properties (for more information, see (Stewart-Brown et al., 2009)). Previous research shows negative correlations ($r = -0.50$, r-squared $= 0.25$) with measures of mental ill-health such as depression symptoms, suggesting that only 25% of the variation in MWB is accounted for by the variation in depression symptoms (Weich et al., 2018). The fact the two are not perfectly correlated suggests that MWB is not merely a proxy for mental ill-health, but rather a measure that extends the range in a positive direction.

Finally, cut-points for SWEMWBS have been proposed in prior research (Santini et al., 2020; Stewart-Brown et al., 2015) for three population groups in the Danish general population: a low MWB category, a moderate MWB category, and a high MWB category. These cut-point have recently been shown to significantly predict differential risk for common mental disorders (Santini et al., 2021). The cut-points for SWEMWBS are as follows (on the transformed metric score): low MWB 7.00–19.98 (or 7–22 without conversion to metric score); moderate MWB 19.99–29.30 (or 23–32 without conversion to metric score); high MWB 29.31–35.00 (or 32–35 without conversion to metric score). SWEMWBS was included in the EHIS survey, and in this study, we utilized as our predictors: 1) the SWEMWBS continuous variable measured in 2019, and 2) the SWEMWBS categorical variable measured in 2019 (low as reference category).

2.4. Covariates

The selection of covariates was based on correlates of absenteeism from the workplace due to illness and mental health/wellbeing (Bergström et al., 2014; Keyes & Grzywacz, 2005; Sears et al., 2013; Shi et al., 2013; Vuorio et al., 2019). Data on gender, age, marital status, education, activity limitations, and pain came from the baseline survey, while data on country of origin, chronic conditions, and any past or current mental disorder came from register data in 2019 (Lynge et al., 2011; Pedersen, 2011). The sociodemographic variables were as follows: age; gender (female, male); country of origin (Denmark; other); marital status (never married or in a registered partnership; married or registered partnership; widowed; divorced); education (primary/10th grade; high school or vocational; tertiary or higher education).

Four variables pertaining to health status were included. To classify the presence of chronic conditions, we used the Charlson Comorbidity Index (CCI). It is based on 19 different medical conditions, each weighted and assigned 1–6 points according to its potential impact on mortality (Thygesen et al., 2011). In accordance with previous literature (Deleuran et al., 2013; Grann et al., 2013; Raedkjaer et al., 2018; Tuty Kuswardhani et al., 2020) and because the distribution of the 1–6 point scale was highly skewed, the CCI score was categorised into three comorbidity levels: CCI=0, CCI=1–2), CCI≥3.

Activity limitations were assessed by asking participants whether (and to which degree) they were limited because of a health problem in activities people usually do. Response categories were "not limited at all", "limited but not severely", and "severely limited". Participants were also asked how much bodily pain they had experienced during the past 4 weeks. Responses ranged from 1 to 6 and were as follows: 1 "none", 2 "very mild", 3 "mild", 4 "moderate", 5 "severe", and 6 "very severe". Finally, any past or current mental disorder was coded as present if any diagnosis (ICD-10 codes F00-F99) was listed for the period 1992–2019.

2.5. Statistical analysis and economic approach

STATA version 16 was used to perform all analyses. The statistical analyses conducted were as follows. First, descriptive analyses (Ns and weighted percentages) were made for the analytical sample. Subsequently, means (unadjusted) were computed to compare the number of sick days in 2020 for the different MWB categories. Finally, similar to previous studies (Campbell et al., 2017; Jinnett et al., 2017; Johnston et al., 2019; Keyes & Grzywacz, 2005; Sears et al., 2013; Tsuchiya et al., 2012; Van Wormer et al., 2017), linear regression analyses were performed. Although the distribution for sick days was skewed, linear regression was used because our aim was to estimate the actual number of sick days associated with each increase in MWB, and because prior research has shown that violations of the normality assumption does not noticeably impact results when using large datasets (Schmidt & Finan, 2018). We estimated the number of sick days (sick days in 2020 controlling for sick days in 2019 and other covariates) associated with (1) each point increase in MWB (continuous SWEMWBS variable), and (2) higher levels of MWB as compared to low MWB (categorical SWEMWBS variable). For each analysis estimating the number of sick days, Model 1 adjusted for age (continuous), gender (categorical), country of origin (categorical), marital status (categorical), education (categorical) and sick days in 2019 (continuous) (we adjusted for sick days in the past year because these are generally strongly correlated with future sick days), while Model 2 adjusted for all the aforementioned variables as well as chronic conditions (categorical), any past or current mental disorder (categorical), pain (continuous) and activity limitations (categorical). We performed the Model 2 analyses in order to avoid inflated results due to confounding by physical or mental health problems at baseline. However, since we already adjusted for prior sick days in 2019, this also ran the risk of overadjustment. Hence, similar to this approach reported previously (Santini et al., 2021a, 2021c), we performed both models as a means to be able to compare the results and evaluate the influence of adjustment variables. In all analyses, survey weights were applied to reduce the possible impact of non-response bias and attrition on the estimates. The weights were computed based on information on gender and age for all individuals who were invited (Rosendahl Jensen et al., 2021). Thus, we ran regression models using number of sick days as the outcome, and subsequently applied average wage rates to the results.

Two economic approaches were used in this study, the Human Capital Approach (HCA) and the Friction Cost Approach (FCA). The HCA is the most traditional approach for estimating lost productivity due to time absent from work due to illness (Pike & Grosse, 2018). This work time lost is then valued at the market wage, which in a competitive market is assumed to reflect the value of that work to society. The FCA was developed in response to criticisms of the HCA generating over-estimated costs from a societal perspective (Koopmanschap et al., 1995). The FCA proposes that society only incurs losses during the period it takes to replace a worker (the 'friction period') due to illness, with internal or external labor reserves or capital equipment. In other words, whereas the HCA assumes that work will be lost for the entire period that a worker is absent due to illness, the FCA assumes that there is a pool of internal workers or external unemployed workers who can take over the role, or it is possible to use technology to substitute for the worker.

Under the FCA, losses are also valued using the market wage, but the amount of lost work is limited to the friction period. A friction period of

Table 1
Characteristics of the study sample.

	Characteristic	Category	N (weighted %)
Baseline	Unweighted N		1959
	Age (continuous)	Mean (SD)	48.1 (10.2)
		Missing	0 (0.0)
	Gender	Female	1151 (50.0)
		Missing	0 (0.0)
	Marital status	Never married/ registered partnership	192 (11.0)
		Married or in registered partnership	1553 (79.3)
		Widowed	14 (0.6)
		Divorced	200 (9.1)
		Missing	0 (0.0)
	Country of origin	Other (not Denmark)	149 (7.8)
		Missing	0 (0.0)
	Education	Primary-10th grade	106 (5.1)
		High school or vocational	692 (35.3)
		Tertiary	1161 (59.7)
		Missing	0 (0.0)
	Activity limitations	Not limited	1499 (78.4)
		Limited to some extent	435 (20.7)
		Severely limited	18 (0.9)
		Missing	7 (0.4)
	Chronic comorbidity index (CCI)	CCI=0	1874 (96.1)
		CCI=1–2	79 (3.5)
		CCI≥3	6 (0.3)
		Missing	0 (0.0)
	Any mental disorder	Present	9 (0.5)
		Missing	0 (0.0)
	MWB[a] (continuous)	Mean (SD)	25.6 (4.5)
		Missing	41 (2.0)
	MWB (categorical)	Low	216 (12.3)
		Moderate	1283 (67.3)
		High	419 (20.4)
		Missing	41 (2.0)
	Number of sick days (HCA range 0–254)	Mean (SD)	11.3 (30.5)
	Number of sick days (FCA range 0–90)	Mean (SD)	9.4 (21.1)
		Missing	0 (0.0)
Follow-up			
	Number of sick days (HCA range 0–254)	Mean (SD)	14.1 (33.2)
	Number of sick days (FCA range 0–90)	Mean (SD)	11.8 (22.6)
		Missing	0 (0.0)

Data are n (weighted%) unless otherwise specified.
[e]Based on the Short Warwick-Edinburgh Mental Wellbeing Scale (range 7–35).

Table 2
Unadjusted mean number of sick days in 2020 per person by mental wellbeing (MWB) categories (measured in 2019) among Danish employed adults aged 16–64 years.

	Low MWB		Moderate MWB		High MWB	
	Mean (days)	95% CI	Mean (days)	95% CI	Mean (days)	95% CI
Number of sick days (HCA range 0–254)	23.27	17.05, 29.50	12.74	11.01, 14.47	9.92	7.59, 12.26
Number of sick days (FCA range 0–90)	18.64	14.77, 22.51	10.78	9.58, 11.97	8.76	6.93, 10.59

Table 3
Associations between sick days per person in 2020 and mental wellbeing categories (MWB - measured in 2019) among Danish employed adults aged 16–64 years.

	Model 1		Model 2	
	HCA			
	Marginal effect	95% CI	Marginal effect	95% CI
MWB (continuous[a])	−0.45	−0.77, −0,14	−0.38	−0.69, −0.06
MWB (categorical)				
- Low	Ref.		Ref.	
- Moderate	−6.72	−12.16, −1.27	−5.84	−11.23, −0.46
- High	−9.57	−15.26, −3.89	−8.51	−14.16, −2.84
	FCA			
	Marginal effect	95% CI	Marginal effect	95% CI
MWB (continuous[a])	−0.37	−0.60, −0.14	−0.30	−0.53, −0.07
MWB (categorical)				
- Low	Ref.		Ref.	
- Moderate	−5.37	−8.91, −1.82	−4.60	−8.18, −1.03
- High	−7.43	−11.33, −3.52	−6.44	−10.41, −2.46

Model 1 is adjusted for age, gender, country of origin, education, marital status, and sick days in 2016.
Model 2 is adjusted for all the aforementioned covariates, as well as chronic conditions, any past or current mental disorder, and pain, and activity limitations.
[a] Short Warwick-Edinburgh Mental Well-being Scale (SWEMWBS) – range 7 (low) −35 (high).

3 months (or 90 days) is a standard used in international studies (Kigozi et al., 2016) as well as in Danish reports (Bilde et al., 2003; Koch et al., 2011), and therefore also used in this study. When studies on productivity losses have included the two approaches, the FCA often generates lower estimates as compared to the HCA (Koopmanschap et al., 1995; Pike & Grosse, 2018). Further, it is common to estimate productivity losses based on statistical averages (rather than individual incomes) (Haddix et al., 2002; Max et al., 2004). We used the conventional approach of using average wage rates instead of individual level wage data. This was done to avoid bias in the estimated productivity values because some groups (young age, being female) have lower wage even though they have the same job tasks. Average wage rates were taken from from Statistics Denmark (DST, 2022), as well as national employment rates also from Statistics Denmark (DST 2022). All productivity loss estimates were in 2020 prices (DKK) and results were subsequently converted to USD PPP (United States Dollars - USD, Purchase Power Parity - PPP) using an online conversion tool (2020 rates for price and target year, PPP values from the International Monetary Fund, 1DKK=USD$0.14 PPP) (EPPI-Centre 2022). Finally, based on employment rate data from Statistics Denmark (DST 2022), statistically significant results were extrapolated to the Danish population of employed adults aged 16–64 years and expressed in USD PPP. All extrapolated estimates are based on model 2 results. In all models, we have reported the point estimate as well as each limit within 95% confidence intervals (Amrhein et al., 2019; Santini et al., 2021c).

3. Results

Information regarding the sociodemographic distributions of the study sample is shown in Table 1. The mean age of the study population was 48.1 years, with 50.0% of the participants being female.

Unadjusted mean number of sick days by MWB categories are shown in Table 2. As can be seen, the average number of sick days in 2020 were consistently lower for each category with a higher level of MWB.

For the analytical statistics, only model 2 results are reported here in

Table 4
Unadjusted productivity cost estimates (reported as USD PPP) in 2020 per person by mental wellbeing (MWB) categories (measured in 2019) among Danish employed adults aged 16–64 years.

	Average monthly salary[a]	Average daily salary[b]	Average number of sick days[c]	Per person cost estimate	Average number of sick days[c]	Per person cost estimate
			Low MWB			
			HCA		**FCA**	
Point estimate	5848.16	276.29	23.27	6429.29	18.64	5150.06
Lower bound estimate	5848.16	276.29	17.05	4710.76	14.77	4080.82
Upper bound estimate	5848.16	276.29	29.50	8150.58	22.51	6219.31
			Moderate MWB			
			HCA		**FCA**	
Point estimate	5848.16	276.29	12.74	3519.95	10.78	2978.42
Lower bound estimate	5848.16	276.29	11.01	3041.96	9.58	2646.87
Upper bound estimate	5848.16	276.29	14.47	3997.93	11.97	3307.20
			High MWB			
			HCA		**FCA**	
Point estimate	5848.16	276.29	9.92	2740.81	8.76	2420.31
Lower bound estimate	5848.16	276.29	7.59	2097.05	6.93	1914.70
Upper bound estimate	5848.16	276.29	12.26	3387.33	10.59	2925.92

Note. Lower bound estimate = 95%CI lower bound limit; Upper bound estimate = 95%CI upper bound limit. USD PPP = U. S. Dollars adjusted by Purchasing Power Parity. All prices are converted from DKK (Danish Krone).
[a] Average monthly salary extracted from Statistics Denmark (see Methods section).
[b] Average daily salary calculated by multiplying with 12 and dividing by 254 (the number of work days in 2020).
[c] Taken from Table 2.

Table 5
Productivity costs (reported as USD PPP) per person in 2020 associated with 2019 mental wellbeing (MWB) – continuous measure.

	Average monthly salary[a]	Average daily salary[b]	Number of sick days[b]	Per person costs	Number of sick days[b]	Per person costs
			MWB (per point increase)			
			HCA		**FCA**	
Point estimate	5848.16	276.29	−0.38	−104.99	−0.30	−82.89
Lower bound estimate	5848.16	276.29	−0.69	−190.64	−0.53	−146.43
Upper bound estimate	5848.16	276.29	−0.06	−16.58	−0.07	−19.34

Note. Lower bound estimate = 95%CI lower bound limit; Upper bound estimate = 95%CI upper bound limit. USD PPP = U. S. Dollars adjusted by Purchasing Power Parity. All prices are converted from DKK (Danish Krone).
[a] Average monthly salary extracted from Statistics Denmark (see Methods section).
[b] Taken from Table 3.

Table 6
Productivity costs (reported as USD PPP) per person in 2020 associated with 2019 mental wellbeing (categorical measure – low as reference category).

	Average monthly salary[a]	Average daily salary[b]	Number of sick days[c]	Per person costs	Number of sick days[c]	Per person costs
			Moderate MWB			
			HCA		**FCA**	
Point estimate	5848.16	276.29	−5.84	−1613.54	−4.60	−1270.94
Lower bound estimate	5848.16	276.29	−11.23	−3102.75	−8.18	−2260.06
Upper bound estimate	5848.16	276.29	−0.46	−127.09	−1.03	−284.58
			High MWB			
			HCA		**FCA**	
Point estimate	5848.16	276.29	−8.51	−2351.24	−6.44	−1779.31
Lower bound estimate	5848.16	276.29	−14.16	−3912.28	−10.41	−2876.19
Upper bound estimate	5848.16	276.29	−2.84	−784.67	−2.46	−679.68

Note. Lower bound estimate = 95%CI lower bound limit; Upper bound estimate = 95%CI upper bound limit. USD PPP = U. S. Dollars adjusted by Purchasing Power Parity. All prices are converted from DKK (Danish Krone).
[a] Average monthly salary extracted from Statistics Denmark (see Methods section).
[b] Average daily salary calculated by multiplying with 12 and dividing by 254 (the number of work days in 2020).
[c] Taken from Table 3.

text (model 1 and 2 showed the same overall pattern, with model 2 results slightly attenuated; both model 1 and model 2 results are shown in Table 3). Table 3 shows the adjusted number of sick days (reported as HCA/FCA) associated with 1) the continuous MWB measure, and 2) the MWB categories. Each point increase in MWB was associated with −0.38 (95%CI −0.69, −0.06) / −0.30 (−0.53, −0.07) sick days per person in 2020 using HCA and FCA respectively. As compared to the low MWB category, moderate MWB was associated with −5.84 (−11.23, −0.46) / −4.60 (−8.18, −1.03) sick days per person in 2020, while high MWB was associated with −8.51 (−14.16, −2.84) / −6.44 (−10.41, −2.46)

Table 7
Extrapolated productivity costs (reported as USD PPP) in 2020 associated with 2019 mental wellbeing (MWB) categories (as compared to low mental wellbeing) for the Danish employed population aged 16–64.

	Total number of persons in employment[a]	% with MWB category [b]	Number of employed persons in MWB category	Per person costs[c]	Extrapolated estimate	Per person costs[c]	Extrapolated estimate
				Moderate MWB			
				HCA	**FCA**		
Point estimate	2,716,138	67.3	1,827,961	−1,613.54	−2,949,486,575	−1270.94	−2,323,225,727
Lower bound estimate	2,716,138	67.3	1,827,961	−3,102.75	−5,671,701,067	−2260.06	−4,131,301,401
Upper bound estimate	2,716,138	67.3	1,827,961	−127.09	−232,322,573	−284.58	−520,200,543
				High MWB			
				HCA	**FCA**		
Point estimate	2,716,138	20.4	554,092	−2,351.24	−1,302,801,469	−1779.31	−985,903,815
Lower bound estimate	2,716,138	20.4	554,092	−3,912.28	−2,167,763,668	−2876.19	−1,593,673,713
Upper bound estimate	2,716,138	20.4	554,092	−784.67	−434,777,459	−679.68	−376,603,010

Note. Lower bound estimate = 95%CI lower bound limit; Upper bound estimate = 95%CI upper bound limit. USD PPP = U. S. Dollars adjusted by Purchasing Power Parity. All prices are converted from DKK (Danish Krone).
All extrapolations are based on model 2 results.
[a] Number of employed persons (age 16–64) extracted from Statistics Denmark (see Methods section).
[b] Weighted percentages from survey data, taken from Table 1.
[c] Taken from Table 6.

sick days per person in 2020.

All results that include productivity loss or costs (reported as HCA/FCA) were converted (from DKK) and are presented in USD PPP in the main tables; the original results expressed in the Danish currency DKK are shown in Appendix. Unadjusted cost estimates by MWB categories are shown in Table 4. The average unadjusted productivity loss for the low MWB category for the HCA/FCA categories respectively was $6429/$5150 per person in 2020, the unadjusted productivity loss for moderate MWB was $3520/$2978 per person in 2020, while the unadjusted productivity loss for high MWB was $2741/$2420 per person in 2020.

Table 5 shows the adjusted value of productivity loss or costs associated with the continuous MWB measure, and Table 6 shows the adjusted value of costs associated with the MWB categories. Table 5 shows that each point increase in MWB for HCA/FCA respectively was associated with $-105/$-83 in lower productivity loss per person in 2020. As compared to the low MWB category with adjusted mean productivity loss of $38,434/$31,632 per person in 2020 (this value reported only in text), Table 6 shows that moderate MWB was associated with a reduction in productivity loss per person in 2020 of $-1614/$-1271, while high MWB was associated with even greater reduction in productivity loss per person in 2020 of $-2351/$-1779.

Table 7 shows the extrapolation of results to the Danish employed population aged 16–64 in 2020 (population size of 2.7 M). As compared to low MWB, moderate MWB (67.3% of the population) was associated with productivity loss that was lower by $-2.9bn/$-2.3bn, while high MWB (20.4% of the population) was associated with productivity loss that was lower by $-1.3bn/$-0.9bn.

4. Discussion

In this study, we set out to estimate the association between mental wellbeing (MWB) and productivity loss or costs (USD PPP) due to sickness absence in the subsequent year. We estimated productivity loss using both the Human Capital Approach (HCA) and the Friction Cost Approach (FCA), reported in that order (HCA/FCA). In line with previous findings (De Neve et al., 2013; Isham et al., 2021, 2019; Krekel et al., 2019), our results confirmed our first hypothesis by showing that our continuous variable for MWB was inversely associated with future loss to productivity. That is, each point increase in MWB in 2019 was associated with $-105/$-83 in lower productivity loss per person in 2020. In terms of our categorical predictor, we also found support for our second hypothesis: as compared to low MWB, moderate MWB was associated with $-1614/$-1271 in lower productivity loss per person in 2020, while high MWB was associated with $-2351/$-1779 in lower productivity loss per person in 2020. These are particularly strong findings, given that all models adjusted for the number of sick days in the previous year, since these are known to be highly correlated with future sick days (Borg, Hensing & Alexanderson, 2004; Sears et al., 2013). We also adjusted for sociodemographics and a range of variables pertaining to physical and mental health status, disability, and pain, which may influence differences in absence from work due to illness. Further, it may be noted that the healthy, well-educated population was over-represented in the study sample. Together these factors suggest we are likely to have under-estimated costs.

Our results suggest that the inverse relationship between MWB and productivity loss is not solely accounted for by a specific vulnerable group of individuals that drive up costs due to being characterised by, for example, high levels of previous work absence due to illness, lower education, or mental or somatic health problems. Rather, our results indicate that the greatest reduction in productivity loss could potentially be achieved when MWB is maximised among as many people as possible in a population. Our results also indicate that improvements in MWB may generate a positive return on investment in the very short term. An intervention costing $103/$81 per individual per year and generating a one-point increase in the SWEMWBS scale, would appear to be cost neutral, but with the added social good of improved MWB among workers. Such assertions depend on evidence to show that MWB can be improved over a short time period and higher levels of MWB sustained, and the evidence base for this is now growing (Enns et al., 2016; Kalra et al., 2012; Sears et al., 2013; VanderWeele, 2020). Specifically in terms reducing sick days, Sears, Shi (Sears et al., 2013) conducted an intervention among 11,700 employees working in a large company. They found that change in wellbeing (using a scale ranging from 0–100) during this intervention resulted in significantly fewer days absent ($\beta = -0.02$, $p < 0.01$).

Finally, we extrapolated our results to the Danish population of employed adults aged 16–64 years (population size of 2.7 M). As compared to low MWB (12.3% of the population), moderate MWB (67.3%) was associated lower productivity loss amounting to $-2.9bn/$-2.3bn, while high MWB (20.4%) was associated with lower productivity loss amounting to $-1.3bn/$-0.9bn. Additionally, we have followed recommendations to assess the implications of each limit within our confidence intervals (Amrhein et al., 2019; Santini et al., 2021c). It may be observed that even the lowest values within these intervals are substantial and warrant attention. Considering the large differences in productivity loss between the different MWB categories, the potential return on investment for programs and policies that promote MWB would be sizable and financially well worth the effort. According to previous reviews (Bealing, 2021) and case-studies (McDaid et al., 2008), businesses that invest in company-wide MWB initiatives can (upon successful implementation) expect a 4–8-fold return on investment within a year due to improved productivity (other similar reports also make the case (see Henke et al., 2011; McDaid et al., 2017; PricewaterhouseCoopers 2008; Sinclair & Sinclair, 2021)). Higher levels of wellbeing may only be valuable for employers, but employees also place a high value on wellbeing in the workplace. For example, a recent study showed that UK workers would be willing to take a 10% pay cut to work for an employer where staff enjoy above average levels of wellbeing (Ward, 2022). Policy and research priorities formed by the European Commission and the World Health Organization support the view that a focus on promoting mental health and wellbeing is crucial for long-term growth and sustainable development (EU, 2019; Forsman et al., 2015; WHO 2005). Strategies should be comprehensive, and may involve approaches such as universal public mental health promotion in the whole population (Fusar-Poli & Santini, 2021; Koushede & Donovan, 2022; Salazar de Pablo et al., 2020; van Agteren et al., 2021), specific interventions in various settings or tailored toward specific segments of the population (Salazar de Pablo et al., 2020; van Agteren et al., 2021), workplace interventions and the promotion of positive workplace cultures (Cameron et al., 2011; Green et al., 2017; Harter et al., 2003; Rath & Harter, 2010), as well as collaborative approaches between workplaces and the local community (Nielsen et al., 2021; Rath & Harter, 2010; Santini et al., 2021). The intervention conducted by Sears et al. (2013) aimed to create a workplace culture of wellbeing, which consisted of personalized wellbeing plans, access to a self-directed Web portal containing resources and support, telephonic coaching for lifestyle and chronic condition management, health education courses, and health and wellbeing messaging around the workplace. A more recent prospective cohort study of 24,990 public hospital employees in Denmark showed that improvements in various psychosocial work environment factors could potentially bring about a 30% reduction in sickness absence (Mathisen et al., 2022). Other literature on wellbeing interventions in the workplace can be found elsewhere (Clifton & Harter, 2021).

Our results add to a growing evidence base (Birkjær et al., 2021; Knapp et al., 2011; Nurse et al., 2014) suggesting that increasing the number of individuals in the population with higher levels of MWB could have the potential added benefit of curbing productivity loss pertaining to sickness absence. It should be noted that although the results of the present study show that MWB is associated with lower productivity loss in the following year, we cannot make firm inferences regarding causal connections. For example, we cannot exclude the possibility that in the years prior to the survey, healthier lifestyles could have predicted both higher levels of MWB and reduced absenteeism. That said, our results align with previous evidence showing that change in wellbeing (as a result of an experimental manipulation or an intervention) is predictive of reductions in loss to productivity (Anderzén & Arnetz, 2005; Halliwell, 2010; Isen & Reeve, 2005; Joseph et al., 2018; Oswald et al., 2015; Sears et al., 2013; Spetch et al., 2011).

In terms of our economic approaches, while the HCA is more widespread and considered a more standard approach when evaluating loss to productivity, the FCA is generally considered more conservative. Studies commonly report lower estimates when using the FCA as compared to the HCA (Kigozi et al., 2016; Pike & Grosse, 2018), and this was also the case in our present study. Both approaches have their limitations and involve a number of uncertainties. For example, the HCA may be more valid when unemployment is low, since lower unemployment rates would reduce the likelihood of replacing workers (unemployment ranged from 3.9 to 5.1% in Denmark in 2020). On the other hand, the FCA assumes that there is a pool of available workers, which is considered to be more applicable when unemployment is high (Pike & Grosse, 2018). Further, when using the FCA, some additional uncertainties are introduced, particularly that friction periods are often unknown (we did not have data on actual friction periods available), and some studies also include estimates for the time it takes to train a replacement worker in a new role. In our FCA analysis, we used a standard friction period of 90 days, and did not make any assumptions regarding the time needed to train new workers. Had this data been available to us, it could potentially have produced different results. Given the ongoing debate over the most appropriate methods for estimating lost productivity, we have taken a pragmatic approach by including both HCA and FCA based analyses. This will allow researchers and decision makers to choose which estimate to use based on their economic or philosophical viewpoint.

Major strengths include the prospective design, the use of a validated scale for measuring MWB, and the use of a population-based survey linked with data from national registers on an individual level. This approach made it possible to make direct links between MWB in one year and registered sickness absence in the subsequent year. Although we relied on self-report data in terms of sick days up to 30 days, sick days exceeding this threshold were based on register-data, which is more reliable. Some limitations are as follows: First, the response rate was 47.4%, and while this is relatively high for a web-based/paper-based survey, selection bias cannot be ruled out. Unit non-response was associated with male gender, younger age, being unmarried, and lower educational level (Rosendahl Jensen et al., 2021). This bias in the study sample, however, serves to reassure that the findings are related to variation in MWB in the well population. It may also be noted that while the proportion of baseline participants that took part in the follow-up survey was relatively high (75.4%), there is a possibility for attrition bias in this part of the study. We have applied non-response and attrition weights in all analyses to reduce the risk of bias. Second, it may be observed that the time period for self-reported sick days in the past year may not have matched perfectly with the register-data for sick-days within the past year. Some overlap was unavoidable since the survey data had been collected over a time period rather than at one fixed time-point. Further, Danish register-data pertaining to sickness absence is recorded for each week absent. Our data does not allow us to make completely precise estimates for the number of sick days within a year. It may also be considered that our extrapolated estimates are based on population numbers in the workforce, but they do not take into account that some proportion may be absent from work for other reasons (e.g., maternity/paternity leave) and also that not all workers work full time. For this reason, our extrapolations are rough estimates, and our most robust findings are those pertaining to per person costs associated with MWB.

Finally, it may be noted that the follow-up survey took place in 2020, which was the first year of the COVID-19 pandemic. The Danish government initiated a lockdown of society (encouraging people to work from home when possible) on the 11th of March 2020, and later initiated a gradual reopening of society on the 17th of April 2020. Another lockdown was initiated again on the 16th of December 2020, which lasted until the 1st of March 2021. Although our study was specifically focused on the association between MWB in 2019 (well before the pandemic) and sick days in the following year, we cannot exclude the possibility that the associations would differ to some extent if the assessment of sick days at follow-up had taken place in times without a pandemic. On that note, given that our predictor in 2019 was inversely associated with sick days during the COVID-19 pandemic in 2020, it may be indicative that higher levels of MWB confer resilience (i.e., coping well in the face of challenges) through the course of a global crisis, including those presented in the context of work. This in itself is an important finding.

In this study, our final results are based on analytical models that

Table A1
Unadjusted productivity cost (reported as DKK) estimates in 2020 per person by mental wellbeing (MWB) categories (measured in 2019) among Danish employed adults aged 16–64 years.

	Average monthly salary[a]	Average daily salary[b]	Average number of sick days[c]	Per person cost estimate	Average number of sick days[c]	Per person cost estimate
			Low MWB			
			HCA		**FCA**	
Point estimate	42,592.14	2012.23	23.27	46,824.52	18.64	37,507.91
Lower bound estimate	42,592.14	2012.23	17.05	34,308.47	14.77	29,720.59
Upper bound estimate	42,592.14	2012.23	29.50	59,360.70	22.51	45,295.23
			Moderate MWB			
			HCA		**FCA**	
Point estimate	42,592.14	2012.23	12.74	25,635.77	10.78	21,691.81
Lower bound estimate	42,592.14	2012.23	11.01	22,154.62	9.58	19,277.14
Upper bound estimate	42,592.14	2012.23	14.47	29,116.93	11.97	24,086.36
			High MWB			
			HCA		**FCA**	
Point estimate	42,592.14	2012.23	9.92	19,961.29	8.76	17,627.11
Lower bound estimate	42,592.14	2012.23	7.59	15,272.80	6.93	13,944.73
Upper bound estimate	42,592.14	2012.23	12.26	24,669.90	10.59	21,309.48

Note. Lower bound estimate = 95%CI lower bound limit; Upper bound estimate = 95%CI upper bound limit.
[a] Average monthly salary extracted from Statistics Denmark (see Methods section).
[b] Average daily salary calculated by multiplying with 12 and dividing by 254 (the number of work days in 2020).
[c] Taken from Table 2.

adjusted for health status, disability, and pain (apart from demographics and socioeconomic factors), which led to some attenuation in the results. We did this to minimize the confounding of such factors; however, overadjustment is a possibility, as we already adjusted for past sick days, hence, we conducted two models with and without the adjustment for health factors. It may further be considered that our results capture reductions in productivity loss associated with higher levels of MWB over the short-term (costs estimated one year following baseline assessment), but not stable levels of high MWB over the longer term (e.g., high MWB over repeated assessments/years). Also, as the study population were restricted to individuals being employed there is a risk of bias related to the hypothesis of the 'healthy worker' effect (Hartvigsen et al., 2001). This hypothesis suggests that the prevalence of any health-related exposure (including MWB) will be underestimated because individuals with health challenges may already have left the labor market. As the consequence of this bias is likely to leave our estimates conservative, we believe that this is a minor problem.

Some additional reflections should also be made in terms of the scope of our study and its implications. In this study, we were not able to estimate various other related cost outcomes pertaining to productivity due to lack of data (e.g., job performance and production output, career development and skill acquisition, presenteeism, unpaid work) (Keyes & Grzywacz, 2005; Sears et al., 2013; Shi et al., 2013), or retention (e.g., intention to stay, job turnover) (Sears et al., 2013; Shi et al., 2013). It is also possible that fewer sick days as a result of higher MWB levels could have an impact on overhead costs (e.g., administrative costs relating to employees going on sick leave and finding temporary or permanent replacements), but we did not have access to administration cost data. Also, our study design did not allow for estimating the costs of long-term productivity loss, i.e., early retirement/disability pensions since MWB does not involve a diagnosis on which disability pensions are based, but other studies have documented inverse associations between wellbeing and intentions to retire early (Siegrist et al., 2007) as well as risk for disability retirement (Harkonmäki et al., 2009). In other words, it is important to keep in mind that our results pertain only to productivity loss due to short-term sickness absence.

5. Conclusion

The results of the present study lend support to and expand prior findings that higher levels of MWB are associated with lower productivity loss or costs in terms of absence from the workplace due to sickness. We estimated productivity loss using the Human Capital Approach (HCA) and the Friction Cost Approach (FCA), reported in that order (HCA/FCA). In terms of our continuous measure for MWB, each point increase was associated with USD PPP $-105/$-83 in lower productivity loss per person in the following year. As compared to low MWB, moderate MWB was associated with lower productivity loss per person of $-1614/$-1271, while high MWB was associated with lower productivity loss per person of $-2351/$-1779. We subsequently extrapolated findings to the Danish population (2.7 M employed adults aged 16–64). As compared to low MWB, moderate MWB (67.3% of the population) was associated with lower productivity loss amounting to $-2.9bn/$-2.3bn, while high MWB (20.4% of the population) was associated with lower productivity loss amounting to $-1.3bn/$-0.9bn. While most efforts focus on the prevention of mental ill-health, our results indicate that substantial reductions in terms of loss to productivity could potentially be achieved by promoting higher levels of MWB in the working population.

Ethics

This study is a secondary data analysis with no human subject issues. Ethics statement is included in the paper.

Data availability

We do not have permission to share data.

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Table A2
Productivity costs (reported as DKK) per person in 2020 associated with 2019 mental wellbeing (MWB) – continuous measure.

	Average monthly salary[a]	Average daily salary[b]	Number of sick days[b]	Per person costs	Number of sick days[b]	Per person costs
			MWB (per point increase)			
			HCA		**FCA**	
Point estimate	42,592.14	2012.23	−0.38	−764.65	−0.30	−603.67
Lower bound estimate	42,592.14	2012.23	−0.69	−1388.44	−0.53	−1066.48
Upper bound estimate	42,592.14	2012.23	−0.06	−120.73	−0.07	−140.86

Note. Lower bound estimate = 95%CI lower bound limit; Upper bound estimate = 95%CI upper bound limit.
[a] Average monthly salary extracted from Statistics Denmark (see Methods section).
[b] Taken from Table 3.

Table A3
Productivity costs (reported as DKK) per person in 2020 associated with 2019 mental wellbeing (categorical measure – low as reference category).

	Average monthly salary[a]	Average daily salary[b]	Number of sick days[c]	Per person costs	Number of sick days[c]	Per person costs
			Moderate MWB			
			HCA		**FCA**	
Point estimate	42,592.14	2012.23	−5.84	−11,751.41	−4.60	−9256.24
Lower bound estimate	42,592.14	2012.23	−11.23	−22,597.31	−8.18	−16,460.02
Upper bound estimate	42,592.14	2012.23	−0.46	−925.62	−1.03	−2072.59
			High MWB			
			HCA		**FCA**	
Point estimate	42,592.14	2012.23	−8.51	−17,124.05	−6.44	−12,958.74
Lower bound estimate	42,592.14	2012.23	−14.16	−28,493.14	−10.41	−20,947.28
Upper bound estimate	42,592.14	2012.23	−2.84	−5714.72	−2.46	−4950.08

Note. Lower bound estimate = 95%CI lower bound limit; Upper bound estimate = 95%CI upper bound limit.
[a] Average monthly salary extracted from Statistics Denmark (see Methods section).
[b] Average daily salary calculated by multiplying with 12 and dividing by 254 (the number of work days in 2020).
[c] Taken from Table 3.

Table A4
Extrapolated productivity costs (reported as DKK) in 2020 associated with 2019 mental wellbeing (MWB) categories (as compared to low mental wellbeing) for the Danish employed population aged 16–64.

	Total number of persons in employment[a]	% with MWB category[b]	Number of employed persons in MWB category	Per person costs[c]	Extrapolated estimate	Per person costs[c]	Extrapolated estimate
				Moderate MWB			
				HCA		**FCA**	
Point estimate	2716,138	67.3	1827,961	−11,751.41	−21,481,110,722	−9256.24	−16,920,052,966
Lower bound estimate	2716,138	67.3	1827,961	−22,597.31	−41,306,998,872	−16,460.02	−30,088,268,101
Upper bound estimate	2716,138	67.3	1827,961	−925.62	−1692,005,297	−2072.59	−3788,620,555
				High MWB			
				HCA		**FCA**	
Point estimate	2716,138	20.4	554,092	−17,124.05	−9488,303,105	−12,958.74	−7180,337,485
Lower bound estimate	2716,138	20.4	554,092	−28,493.14	−15,787,822,792	−20,947.28	−11,606,725,654
Upper bound estimate	2716,138	20.4	554,092	−5714.72	−3166,484,232	−4950.08	−2742,799,722

Note. Lower bound estimate = 95%CI lower bound limit; Upper bound estimate = 95%CI upper bound limit. All extrapolations are based on model 2 results.
[a] Number of employed persons (age 16–64) extracted from Statistics Denmark (see Methods section).
[b] Weighted percentages from survey data, taken from Table 1.
[c] Taken from Table A3.

Contributor statement

All authors have contributed to the work submitted.

Transparency declaration

The manuscript is an honest, accurate, and transparent account of the study being reported. No important aspects of the study have been omitted. Any discrepancies from the study as planned (and, if relevant, registered) have been explained.

Declaration of Competing Interest

No conflicts of interest declared.

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Appendices

Tables A1, A2, A3 and A4

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