

# ‘Hidden epidemic’ of neurological deaths in the major Western nations in the 21<sup>st</sup> Century: Exploring multiple-interactive environmental causes

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**Abstract:** In the first international comparative study of neurological mortality, which found that between 1989 and 1997, and based on the latest WHO available data, twelve of the twenty-one Western countries had substantial increases in neurological deaths (Pritchard et al., 2004) and by 2021 every-one of the twenty-one Western nations had significant rises in neurological deaths (Pritchard et al., 2013, 2017). In this new study presented here, we use WHO data (WHO, 2020) and the ONS (ONS, 2022) data for England and Wales up to 2020. Previously, increases have been assumed largely due to demography and improved accurate diagnostics (the Gompertzian hypothesis). Our results challenge the idea that the increases are mainly due to demography. We explore the multi-interactive environmental factors that have probably contributed to the rising neurological morbidity, ranging from petrochemicals, organophosphates, endocrine-disruptive chemicals, food additives, plastics, heavy metals in water and human breast milk.

**Keywords:** neurological mortality; environmental factors in mental health; diagnosis performance; Gompertzian hypothesis.

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**Dr Colin Pritchard**, who passed away in January 2023, was Research Professor in Psychiatric Social Work, Faculty of Health and Social Sciences, Bournemouth University. Previously, he was Foundation Professor in Social Work Studies, then Research Professor in Psychiatric Social Work in the School of Medicine, University of Southampton. A recent bibliometric analysis identified him as being in the top 10 most impactful British contributors to social work journal scholarship, and in the top 40 globally.

## Introduction

This study is in honour of Professor Peter Huxley, who enjoys a world-wide reputation that crosses the health and social sciences. I have known his work over the years and have often drawn upon his contribution in the field of suicide and mental health (Huxley and Fitzwilliam, 1983; Barr and Huxley, 1999; Huxley et al., 2002, 2003). Not least, is his importance in highlighting social factors in ill-health (Huxley et al., 2017, 2018, 2021). This original study aims to honour to Peter by asking new questions on the importance of social factors in health. This project emerged after a second friend under the age of sixty died from motor neurone disorder. When taught in the early 1960s, we were told that motor neurone disease affected one in twenty-thousand people, which raised the question, is something new occurring? This led to the first international comparative study of neurological mortality, which found that between 1989 and 1997, and based on the latest WHO available data, twelve of the twenty-one Western countries had substantial increases in neurological deaths (Pritchard et al., 2004). In the following studies, by 2010 every-one of the twenty-one Western nations had significant rises in neurological deaths (Pritchard et al., 2013, 2017).

In this new study, we call upon WHO data (WHO, 2020) and the ONS (ONS, 2020) facts for England and Wales up to 2020. It is, in effect, a hypothesis study on the aetiology of these increasing neurological morbidity rates in the 21<sup>st</sup> Century. The study is somewhat controversial as we challenge what might be described as the standard view, that assumes neurological increases are mainly because of an ageing population.

In the international studies, the focus is upon *total* neurological disorders using WHO two global categories (WHO, 2020). These are ‘Nervous Disease Deaths’ (which includes Parkinson’s, motor neurone disease, multiple sclerosis, progressive bulbar palsy, multiple system atrophy and so on), and ‘Alzheimer’s and Other Dementias’ (Alzheimer’s, Pick’s, Other degenerative disorders) (Pritchard et al., 2004, 2013, 2017, 2021). These are more comprehensive neurological conditions than in the ONS (2022) study.

In this controlled study neurological deaths are juxtaposed against All Other Causes of Deaths (AOCD) during the 21<sup>st</sup> Century in the Ten Major Western Nations (TMWN), to explore if there might be a better explanation for accelerating neurological morbidity. The countries are Australia, Canada, France, Germany, Italy, Japan, Netherlands, Spain, the UK, and the USA. The first part examines England and Wales Age-Standardised-Death-Rates (ASDR) for Alzheimer’s, Dementias and Parkinson’s Disease and sixteen major causes of deaths between 2000 and 2020 (ONS, 2022).

The second part is based upon WHO data for total Combined Neurological Mortality (CNM) for Early Adult Deaths, for people aged 55-74, which is well below the average Western life-expectancy (82 years) It therefore tests the Gompertzian hypothesis, and ASDR for the combined two WHO global neurological death rates, which are controlled for population. There are two working null hypotheses. The first is there will be no significant differences between Alzheimer's and other Dementias and All Other Causes of Deaths (AOCD) in England and Wales between 2000 and 2020. The second is there will be no significant difference between Early Adult Deaths (55-74) and total ASDR for Combined Neurological Mortality (CNM) and All Other Causes of Deaths (AOCD) between 2000-2015.

## Methodology

We draw upon the recent UK Office of National Statistics (ONS, 2022) registered deaths for other Dementias (coded G01-03) and Alzheimer's disease (code G30) based upon Age-Standardised-Deaths-Rates (ASDR) for between 2000 and 2020 (ONS 2022). In an earlier study, we used the ONS report on Parkinson's Disease (code G20) between 2001-2018 (ONS, 2020). Together, these three diagnostic neurological groups are combined to give the rates for England and Wales. In the report, they also listed sixteen other major of causes of deaths between 2000 and 2020, which become a natural control for the three neurological deaths over the period.

To examine any statistical difference between neurological and AOCD, ratios of change of the death rates between 2000 and 2020 were used, from which odds ratios were calculated. For an international perspective of measuring changes in neurological deaths, data from the WHO (2020), is examined for the TMWN. To act as a control, we use All Other Causes of Deaths (AOCD) over the period, after excluding neurological deaths. Total neurological deaths are based upon two WHO global neurological diagnostic categories, Nervous Disease Deaths (NDD, coded G00-G99), Alzheimer's Disease (code G30) and Dementia Deaths (F01, F03, G31), from which we calculate the 'Combined Neurological' Mortality ASDR rates. These categories include a wider variation of neurological disease, ranging from motor neuron disease, multiple system atrophy, progressive bulbar pathology, other dementias, multiple sclerosis, progressive isolated aphasia, Picks Disease, Alzheimer's Disease, Parkinson's Disease, and so on.

However, a third WHO category 'Mental and Behavioural Disorders' (coded F10-19), also has some neurological conditions, designated 'neurological conditions not reported elsewhere'. The category also includes deaths such as sub-

stance disorders but not separated for neurological disease. Consequently, we excluded 'Mental and Behaviour Disorder' deaths to ensure we are not over-stating the results. In part, therefore, the final 'Combined Neurological Mortality (CNM) rates will be a slight under-reporting.

The AOCD and the CNM rates are based on total ASDR, but in addition we measure both for deaths of people aged 55-74 years, which are earlier than Western life-expectancy, hence deaths in this age-band can be described Early Adult Deaths (EAD).

The WHO rates for the 21<sup>st</sup> Century come from a base-line of three-year averages of 2000-2002, compared with the latest index average years of 2013-15 for Combined Neurological Mortality (CNM) and AOCD, tested with ratios of change for each category in each country. There were slight differences in index years from 2013-15 found in Canada, whose latest year was 2013 and France 2014, which are noted in the tables. To test between AOCD and CNM we use ratios of change, from which can calculate Odds Ratios. We calculate that any Odds Ratio greater or less than 1:1.20 or 1:0.80 was statistically significant. To provide a more direct practical perception, we transpose the rates back into numbers of deaths for E.A.D (55-74) and total ASDR actual numbers for the UK and USA as exemplars for the other countries.

## **Population Context**

The Gompertzian theory has stressed that neurological diseases are traditionally assumed as mainly age-related. The context for UK population of people aged 55-74 years, rose from 11.10 million people to 13.80, between 2000 and 2015, a rise of 25%. For older adults (75+) in 2000 there were 4.41 million people, rising to 5.19 million by 2015, an increase of 18% over the period. Of course, with regard to mortality rates, figures are controlled for population and ages per million.

## **Results**

### **ASDR (England and Wales)**

Table 1 list the ONS ASDRs for England and Wales for nineteen separate diagnostic categories. The neurological conditions are Dementias, Alzheimer's (2000-2020) and Parkinson's Disease (2001-2018). They are noted in bold. Dementia deaths

Table 1

Age-Standardised-Mortality-Rates per million England and Wales 2000-2020: Ranked Highest Rates – Odds Ratio Other vs Alzheimer's Disease.

Mortality Category 2020 – 2000 Ranks (ICD Code)	Years 2000–2020	Ratio of Change	Others: Alzh Odds Ratios
All Causes (Totals ASMR)	12962–10024	0.77	1:5.82
1-1.Ischemic Heart Disease. 15	2657–1003	0.38	1:11.78
2-9.Dementia G01, G03	233–781	3.35#	1:1.34
3-4.Lung and Bronchial C33-34	714–519	0.73	1:6.14
4-3.Cerebrovascular 160-169	1298–516	0.40	1:11.20
5-5.Bronchitis and Emphysema J40-44	693–455	0.66	1:6.79
6-6.Prostate Cancer C61	551–452	0.82	1:5.46
7-2.Pneumonia J12-18	1353–402	0.30	1:30.0
8-17=.Alzheimer's G30	79–368	4.48#	1:1.00
9-7.Breast cancer C50	457–325	0.71	1:6.31
10-15.Liver Disease K70-77	117–161	1.37#	1:3.27
11-12=.Pancreas Cancer C25	143–154	1.08#	1:4.15
12-9.Colon cancer C18	228–150	0.66	1:5.79
13-10.Oesophagus C15	149–128	0.86	1:5.21
14-11=.Diabetes E10-19	143–124	0.87	1:5.15
15-19.Parkinson's (20001-18) G20	49–100	2.05	1:2.19
16-14.Bladder C50	118–95	0.81	1:5.53
17-17=.Recto-sigmoid C19-21	79–84	1.06#	1:4.23
18-16.Leukaemia C91-95	89–78	0.88	1:5.09
19-17=.Stomach C16	143–64	0.44	1:10.8
Combined Neuro	361–1249	3.46	1:1.29

Rank Order 2000-2020 Rho = +0.8112 p<0.001 Based upon ONS population minimal Neuro 2001 21,340 by 2020 83,784 = ratio 3.93 = 293%.

increased from 233 per million to 781 per million, a ratio of change of 1:3.35, an equivalent of 235% increase. With regard to Alzheimer's Disease, death rates moved from 79 per million to 368 per million, ratio 1:4.66, a rise of equivalent of 347% in just 21 years.

Parkinson's Disease ASDRs went from 49 pm to 100 pm, a ratio of change 1:2.04 during a shorter period of 2001 to 2018.

It should be noted when combining the three neurological categories together, they moved from being 361pm to 1249pm, producing a ratio of change of 1:3.35, thus the England and Wales neurological rates, trebled during this Century, far exceeding any population rises. In 2000, dementia deaths were ninth of the nineteenth categories, by 2020 they were second highest. Alzheimer's Disease moved from equal 17<sup>th</sup> to eighth highest, and Parkinson's Disease moved from lowest to fifteenth.

As expected, liver disease rose substantially (+25%), but the majority of AOCDs reduced considerably. There were notable falls in: ischemic heart disease; cerebrovascular; lung, breast, colon and stomach cancers; and bronchitis and pneumonia, with an average fall for AOC of 23%. Thus, neurological death rates became a significantly greater proportion of all early adult deaths over the period.

In England and Wales there were 21,240 neurological mortalities in 2000. By 2020, there were 83,784 deaths, a ratio of 1:3.94, which is equivalent of a rise of 294% over the period. Practice issues surrounding patients, families, and services will be discussed when we examine neurological deaths in the whole UK.

## **International Combined Neurological Mortality (CNM) v All Other Causes of Death (AOCD)**

### **Early-Adult Deaths (EAD) 55-74 years**

A key focus in challenging the Gompertzian hypothesis is to focus upon mortality rates well below the Western life expectancy of 82 years, hence with people aged 55-74. [Table 2](#) presents the EAD (55-74) neurological deaths, based upon WHO data for the Combined Neurological Mortality (CNM) between 2000-2015. The nations are ranked by the highest neurological mortality rate. Mortality differences over the period are measured by ratios of changes. The highest neurological EAD rates were in the USA and the UK, at 710 per million and 653 per million respectively, the lowest figures being Japan, 206 per million, and France, 440 per million.

Table 2

Western Nations All-Other-Causes-Deaths (AOCD) vs Combined Neurological Mortality (CNM) 55-74 year olds rates per million 2000-02 v 2013-15. Ratio of Change. Ranked by Widest Odds Ratios.

Country and Ratio change	AOCD 55-74 2000 v 2015	CNM 55-74 2000 v 2015	All Countries Odds Ratio
1.USA	14603–10457	511–710	1.93
Ratio change	0.72	1.39	
2.UK	14982–9771	420–653	2.03
Ratio change	0.65	1.32	
3.Netherland	13804–9233	466–602	1.93
Ratio change	0.67	1.29	
4.Spain	12056–8286	494–508	1.49
Ratio change	0.69	1.03	
5.Australia	11090–7458	377–506	2.00
%change	0.67	1.34	
6.Germany	13890–10907	314–478	1.92
Ratio change	0.79	1.52	
7.Canada	11848–8178	535–483	1.30
2013	0.69	0.90 <sup>#</sup>	
Ratio change			
8.Italy	12098–8351	452–460	1.48
Ratio change	0.79	1.02	
9.France	11698–8156	570–440	1.10
Ratio change	0.70	0.77 <sup>#</sup>	
10.Japan	10453–8238	151–206	1.72
%change	0.79	1.36	
Average	0.72	1.30	1.81
Ratio			
Countries			

<sup>#</sup> rate fell over the period.

Two countries, France and Canada, had falls in neurological EADs, with ratios of 1:0.90 and 1:0.77, respectively, i.e., equivalent of falls of 10% and 23%. Conversely, all other countries rates increased. Notable proportional increases over just sixteen years, controlled by population, were in Germany, with a ratio of 1:1.52, Japan (1:1.36), USA (1:1.34), Australia (1:1.34), UK (1:1.32) and Netherlands (1:1.29). For the TMWCs, the average neurological EAD rates in 2000

were 429pm but by 2015 were 505pm, a ratio of change 1:1.18, equivalent to an average overall increase of 18%. With regard to EAD for AOCD, every nation's rates fell substantially (>25%) during this Century, though the highest rate was the USA at 10,457pm, followed by Germany 10,907pm, with the lowest being Australia 7,458pm and France 8,156pm.

There were positive odds ratios between AOCD and CNM in every country, the lowest odds ratio were France 1:1.10 and Canada 1:1.30, with the widest odds ratio of UK 1:2.03 and Australia 1:2.00.

## **Total ASDR Neurological vs All Other Causes Deaths**

Table 3 presents combined neurological ASDRs compared to AOCD for TMWCs during the 21<sup>st</sup> Century. The highest ASDR was the USA at 292pm and the UK 249pm. The lowest rates were in Japan (54pm) and Italy (30pm). The average rise in odds ratio of all countries was 1.48, equivalent of a 48% increase. Rates in all ten countries rose. The narrowest odds ratios were Canada at 1.08 and France at 1.11. All the others rose by at least 20%, the widest being Japan at 1.80, in part because they had such a low baseline. The USA and the UK rises were equivalent to 68% and 95% respectively, in just sixteen years. Every nation's AOCD fell substantially (>25%). Only the USA at 18% and Japan at 19%, were lower. There were significantly wide odds ratios between AOCD and neurological mortality, the narrowest being the neurological outliers of France (1:1.48) and Canada (1:1.52). The widest were the UK at 1:2.75 and the Netherlands 1:2.38, and with greater than 1:2.00 for Australia, Germany, Japan and the USA, highlighting just how diverse the changes between neurological and non-neurological morbidity and mortality in the ten major Western countries.

Rates are statistics but sometimes actual numbers give a better sense of practice implications on patients, families and services. Transposing the rates into numbers of Dementias, Alzheimer's and Parkinson's Disease deaths in England and Wales in 2000 there were 21,340 deaths, but by 2020 they had risen to 83,784 deaths a ratio of 3.93 equivalent of a 293% rise.

Transposing the WHO neurological deaths for EAD in 2000 in Britain it was 4,650 rising to 9,019, up 94%, with total ASDR neurological deaths going from 24,601 to 103,550, equivalent of 321%. In the USA their 55-74 deaths started at 21,818 in 2000 rising to 48,043 a rise of 120%, whilst total American neurological deaths went from 174,708 to 436,430 up 150% in just sixteen years.



Table 3

All Western Nations All-Other-Causes-Deaths vs ASDR Combined Neurological Mortality (ASDR) per million 2000-02 v 2013-15. Odds Ratio of Change Ranked by Highest Rates.

Country and Ratio change	AOCD ASDR 2000-02 v 2013-15	CNM ASDR 2000-02 v 2013-15	All Countries Odds Ratios
1.USA Ratio change	5259-4315 0.82	174-292 1.68	2.05
2.UK Ratio change	4998-3527 0.71	128-249 1.95	2.75
3.Netherland Ratio change	4885-3373 0.69	149-244 1.64	2.38
4.Canada 2013 Ratio change	4246-3286 0.71	182-195 1.08	1.52
5.Germany Ratio change	5469-3803 0,70	124-192 1.55	2.21
6=.Australia %change	4067-3076 0.76	121-188 1.55	2.04
6=.Spain Ratio change	4325-3110 0,;72	155-188 1.21	1.68
8.France Ratio change	4406-3313 0.75	159-176 1.11	1.48
9.Italy Ratio change	4296-3238 0.75	109-130 1.19	1.59
10.Japan %change	3691-3007 0.81	30-54 1.80	2.22
Average Ratios Countries	0.74	1.48	2.00

## Discussion and Multiple-Aetiological Factors

The neurological mortality rates during this Century have obviously substantially increased, many starting earlier. Yet, the ONS and some earlier clinical studies, assumed rises were largely due to demography, improved accurate diagnostics are mainly due to the Gompertzian hypothesis, increased amongst elderly (75+) population (Riggs and Schochet, 1992; Easton, 2005; Goldacre et al., 2010; ONS,

2021). This is NOT to deny that the largest increases of neurological deaths would have been amongst the over 75's, as the Anglo-Welsh elderly population rose 18% over the period 2000-2020. Yet the ONS (2022) Anglo-Welsh mortalities, controlled for age, showed that the Alzheimer's, Dementias, and Parkinson's Disease deaths, rose by 235%, 347% and 102% respectively. Thus, we can challenge the idea that the increases are mainly due to demography.

Whilst the WHO data, covering 2000 to 2015, already showed that 16 of the 21 Western nations Early-Adult-Deaths (55-74) had risen substantially (Pritchard et al., 2017, 2021), as in these six of the then MWN, indicating the conditions are starting much earlier. Whilst all MWN total neurological ASDR deaths rose substantially, even the outliers France rates rose 11% over the period. Whilst reflecting that the UK's neurological deaths number rose from 24,601 to 103,550, and, the American rate from 174,708 to 436,430, has virtually matched a year's Covid-19 deaths in 2020. Moreover, these numbers do not include deaths from WHO 'Mental Behavioural Disorder' category and therefore are an under-estimate. Thus, we can be confident that there are real unprecedented and accelerating neurological deaths during the 21st Century and unlikely to be due to demography or the changing of recording.

There is considerable support for our position from clinical studies on Early-Onset-Dementias mortality, whilst mainly in Western countries, these early neurological deaths are also found in China, the Indian sub-continent and Latin America (Kalaria et al., 2008; Panegyres and Chen, 2014; Sanyal et al., 2014; Cuyvers et al., 2015; Sanchez et al., 2015; Batla et al., 2018; Li et al., 2018; Perone et al., 2018; Rantalainen et al., 2018; Mendez, 2019; Santabárbara et al., 2019; Strand et al., 2019; Han et al., 2020; Velayudhan et al., 2020; Wang et al., 2020; Chiari et al., 2021; de Mettelinge et al., 2021; Spina et al., 2021; Uddin et al., 2021a, b). Whilst in Japan, which still has the least Western neurological prevalence, their Early Onset Dementia rates increased more than their rising older Alzheimer's people (Awata et al., 2020; Hirano et al., 2021). It may be remembered that Scheltens et al. (2021) had predicted a doubling of Alzheimer's disease by 2050, yet our results show that this has almost arrived.

One advantage Professor Peter Huxley and I have is that we have continued to be active researchers for many years and being older, gives the greater ability to see the bigger picture over time. Hence in our life histories, we can understand how our Western world has profoundly changed, at an accelerating speed over the past mere forty years. Of course, in any diagnostic category, we accept Professor Sir Walter Bodmer's adage, "whilst genetics loads the gun, it's the environment that pulls the trigger". This is found in the speed of many of the studies over-taking the genetic linkage with early-onset-dementia during this Century (Panegyres and Chen, 2014; Cuyvers et al., 2015; Batla et al., 2018; Li et al.,

2018; Perrone et al., 2018; Rantalainen et al., 2018). Whilst the link between neurological disease and occupations is well known, especially Parkinson's Disease and motor neurone disease and various occupational risks (Darweesh et al., 2018; Naughton and Terry, 2018; Chen et al., 2019; Fu et al., 2019; O'Callaghan and Miller, 2019; Santabárbara et al., 2019; Huang et al., 2020; Sundström et al., 2020; Farugia et al., 2021; Kivimäki et al., 2021).

This leads us to explore the multi-interactive environmental factors that have probably contributed to the rising neurological morbidity, ranging from petrochemicals, organophosphates, endocrine-disruptive chemicals, food additives, plastics, heavy metals in water and human breast milk (Ross et al., 2013; Belyaev et al., 2016; Scheffler and Dammhahn, 2017; Belpomme et al., 2018; Gore et al., 2019; Pritchard et al., 2019; Scheffler and Damhahan, 2019; Mari et al., 2020; EHT, 2021; Patisaul et al., 2021; Street et al., 2021). In addition is the ubiquity of very low but prolonged exposure to electro-magnetic fields (EMF) (Belpomme et al., 2018; Belyaev et al., 2016; Terzi et al., 2016; Chen et al., 2019).

The European Union guidelines on EMF, commented that manufacturers were mainly concerned with the development of new technology but were less concerned about their possible impact on health, which are now beginning to emerge (Belyaev et al., 2016). We do not wish to over-emphasise upon the digital ubiquitous world, but the American Environmental Health Agency in 2021, successfully sued the Federal Communications Commission because of their inadequacy, where they had virtually ignored the low, but prolonged exposure, of electromagnetism impacting upon health (EHA, 2021). After all it was only in the late 1980's that PCs and mobiles were becoming common and now after thirty years, with a multiplicity of EMF sources, it is thought it might be a trigger that influence the interactive multiplicity range of environmental pollutants (Pritchard et al., 2019). It was Rachel Carson in 1968, who warned in 'The Silent Spring' (Carson, 1968), that the multiplicity of environmental impacts on animals and insects, would eventually effect humans as we forget that we also live in the 'natural world'. She was fiercely attacked by a range of vested interests, as she showed that the organophosphates were basically nerve poisons, that have been confirmed (Ross et al., 2017).

As many of the neurological conditions appear to take a decade or more before they are recognised, we fear this may be similar to an industrial-disease that started in the 1960's that is now producing problems in the 21<sup>st</sup> Century. This relates to asbestosis, which was not totally banned until the 1980's. There are now lung mesotheliomas, that takes decades before the disease presents itself, and are now beginning to be found in the Western world of people in their late fifties and sixties, dying from asbestosis mesothelioma (Kwak et al., 2019; Loomis et al., 2019; Loomis et al., 2019; Luberto et al., 2019; Girardi et al.,

2020; Fazzo et al., 2021). Are our results another example of an environmental impact creating a new wave upon human morbidity?

### **Indebted to Professor Peter Huxley**

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