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Ecological evidence for later dementia diagnosis in areas with higher rates of bilingualism:

Evidence from *Y Fro Gymraeg* in Wales

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Abstract

Background: Bilingualism has been proposed as a protective factor against dementia,

putatively delaying onset by several years. However, evidence is equivocal. One possibility is

that the pattern of confounding varies across contexts, with confounders such as

socioeconomic status, rurality, and migrant status being positively associated with

bilingualism in some settings and negatively in others. The present study examines this in

Welsh-speaking Wales, where the confounding structure differs from much of the literature.

Methods: Routine clinical data from the Memory Clinic service covering the counties of

Gwynedd and Ynys Môn were used to examine the ecological correlation between Welsh-

speaking rates and dementia diagnosis rates by lower super output area. Analyses were

conducted using Poisson generalised linear mixed effects models with spatial auto-

correlation terms.

Results: A total of 404 cases were identified. No overall association was observed between dementia diagnosis rates and Welsh-speaking rates, but the association was moderated by age band, such that Welsh-speaking rates were protective in 65-74 year-olds but a risk factor in 75+ year olds (rate ratio=.71, .53-.94). This was robust to adjustment for area-level poverty.

Conclusion: Although causation cannot be inferred, the findings are consistent with bilingualism delaying dementia onset. Welsh-English bilingualism provides a useful complement to research on this topic elsewhere in the world, as the confounding structure is unusual.

Introduction

With an aging global population, dementia prevalence is set to grow over coming decades (Prince et al., 2013), so identifying modifiable risk factors is vital. One putative protective factor is bilingualism. Since initial work showing that dementia onset appears to be several years later in bilinguals than monolinguals (Bialystok et al., 2007), there has been substantial scientific interest in bilingualism's possible protective status.

Theoretically, bilingualism has been linked to cognitive reserve (Stern, 2002), whereby the functional impact of neurodegeneration is better compensated by individuals with greater education or occupational attainment. Habitually using multiple languages in parallel has been suggested to benefit executive function (Bak et al., 2014), a finding replicated in Canadian (Bialystok et al., 2014) and Indian (Alladi et al., 2013) samples. Furthermore, neuroimaging evidence suggests that bilinguals diagnosed with dementia show greater neural atrophy (Schweizer et al., 2012) and hypometabolism (Perani et al., 2017) than monolinguals with similar functional impairment.

Other studies find no association. Clare et al. (2016) found no difference in onset between Welsh-English bilinguals and monolingual English speakers. Lawton et al. (2015) found no association between bilingualism and onset in Hispanic Americans. Negative findings were also reported in Canadian (Yeung et al., 2014) and American (Sanders et al., 2012) community settings. Other results were equivocal. Chertkow et al. (2010) found a non-significant trend towards a bilingual advantage in their main analysis, but a bilingual advantage in an immigrant subgroup. Alladi and colleagues (Alladi et al., 2017) found a bilingual advantage in some, but not all, fronto-temporal dementia subtypes. Zahodne et al.

(2014) followed a cohort of Hispanic-Americans, finding a protective association with bilingualism in an unadjusted model, which did not survive adjustment for baseline functioning and education.

One possible explanation for this heterogeneity is that bilingualism is not randomly assigned. Being bilingual can be a marker for belonging to an ethnocultural minority and/or migrant status. Such factors could confound any relationship between bilingualism and dementia risk. The 'healthy migrant effect' (Abraído-Lanza et al., 1999) is the tendency for migrants to be healthier on average than residents of both the countries they are migrating from and to, presumably due to health selection factors. Furthermore, the degree of this protective effect appears to be related to the degree of acculturation to the host culture (Marmot & Syme, 1976). Given that observational studies will always face such confounds, a pragmatic approach is to investigate this question across different settings, where the social correlates of bilingualism vary.

The present study looked at patterns of dementia incidence in northwest Wales, specifically the counties of Gwynedd and Ynys Môn. Although the most widely spoken language in Wales is English, approximately 19% also speak Welsh (Office for National Statistics et al., 2016). Gwynedd and Ynys Môn are part of *Y Fro Gymraeg*, the region of west Wales with the highest rates of speaking Welsh. According to the 2011 UK Census, 89% of Gwynedd residents and 78% of Ynys Môn residents born in Wales can speak Welsh, while 20% and 18% respectively of those born outside of Wales can. Thus, migration status, within the UK or internationally, is negatively associated with Welsh-English bilingualism.

This study used routine clinical data from the Memory Clinic service covering these counties to examine whether the geographical distribution of dementia incidence was associated with the distribution of Welsh-English bilingualism.

Methods

This study received ethical approval from the Bangor University School of Psychology Ethics Committee and from West of Scotland REC 5 NHS Research Ethics Committee.

Pre-registration

Planned analyses were pre-registered, before accessing the data (https://osf.io/q6s83). Changes were made to planned analyses, highlighted in the *Departures from pre-registration* section. Further non-pre-registered analyses are identified as such in the text.

Setting

Data are from the Memory Clinic service covering the counties of Gwynedd and Ynys Môn. The unit of geography used here is the lower super output area (LSOA) a unit of census geography with 1000-3000 residents. At LSOA level, Welsh-speaking rates in the two counties vary widely, from 25% (Menai, Bangor) to 90% (Seiont 1, Caernarfon). The region is primarily rural, but includes the university town of Bangor and Holyhead, the UK's main port to Ireland. See Figure 1 for a map of Welsh-speaking rates.

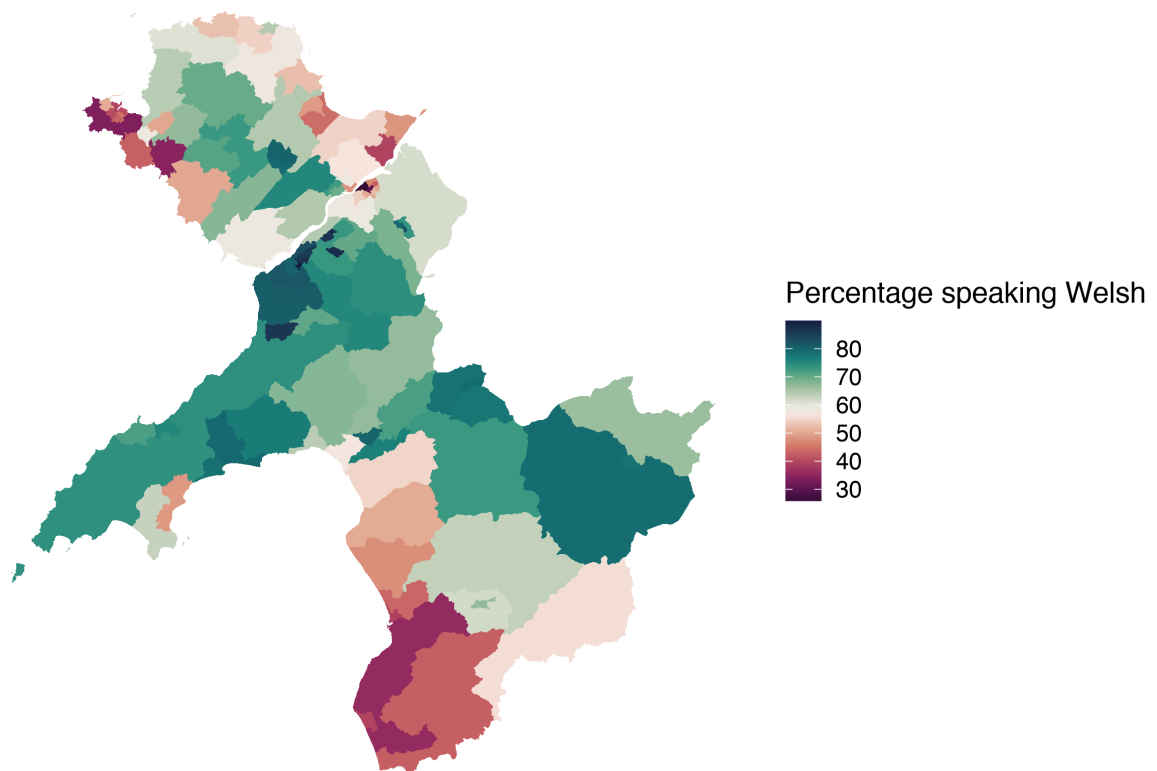*Figure 1. A map of Welsh-speaking rates for each LSOA in Gwynedd and Ynys Môn,*

according to the 2011 UK Census.

Data

Data from all assessments undertaken in the Memory Clinic between November 2014 to

May 2018 were obtained. Clinicians and administrators working within the service

anonymised data before passing them to the first author. Data on age band, LSOA of

residence, sex, and diagnosis were provided.

Analysis

The number of patients given a dementia diagnosis (excluding those not diagnosed or given any non-dementia diagnosis) were computed for each LSOA, stratified by sex and age band (50-64, 65-75, 75+).

These counts were combined with several variables at the LSOA level: a) the proportion of residents aged 65 and over who speak Welsh, b) the population of the given stratum in that LSOA, c) the proportion of the population receiving low income-related benefits (from the Welsh Index of Multiple Deprivation), and d) whether there is a care home for older adults in that LSOA (according to the Care Inspectorate Wales).

Four Poisson-distributed generalised linear mixed models were fitted to the data, each predicting cases in each LSOA for each stratum, with fixed effects of the proportion of 65+ year olds who speak Welsh (z-scored), age band, sex, whether the LSOA has a care home, and an offset term for the logged population at the relevant stratum. Models also contained a random intercept for each LSOA, to account for nesting of data, and a Matérn autocorrelation term, based on LSOA population centroids.

One model included only the above terms. A second model added a term for the proportion of residents in receipt of low-pay related benefits (Welsh Government, 2014). A third model included an interaction between age and the proportion of Welsh speakers, and a fourth contained this interaction and the low-pay term.

The interaction term was not pre-registered, but was included because previous studies suggest that bilingualism delays dementia, so there may be fewer cases identified in younger age groups, but more in older age groups. The presence of a care home was included as a proxy for a concentration of older people with increased frailty in the area. The low pay term was included to adjust for broader social gradients in dementia incidence. All models were fitted using *spamm* (Rousset & Ferdy, 2014) for *R* (R Core Team, 2019)

Departures from pre-registration

The pre-registration proposed to use five years of data for the entire health board. When accessed, data were less complete than hoped: the period with complete data was shorter and only Gwynedd and Ynys Môn had the data needed. Thus, we restricted our analysis to these counties and a shorter timespan (just under 4 years).

The pre-registered analysis did not include age or its interaction with Welsh-speaking rates, or low-pay rates. We report the original version of the analysis as Model 1, but include the other models as we feel that not including these other variables was a mistake in retrospect.

Results

A total of 404 cases were identified across the 117 LSOAs in Gwynedd and Ynys Môn: 343 aged 75+, 54 aged 65-74, and seven aged 50-64. The majority, 254, were female, with 150 male cases.

Figure 2. plots dementia diagnosis rates against Welsh-speaking rates, stratified by age. The relationship differs by age: in 65-74 year olds, higher proportions of Welsh speakers are associated with lower rates, while in 75+ year olds, this is associated with higher rates.
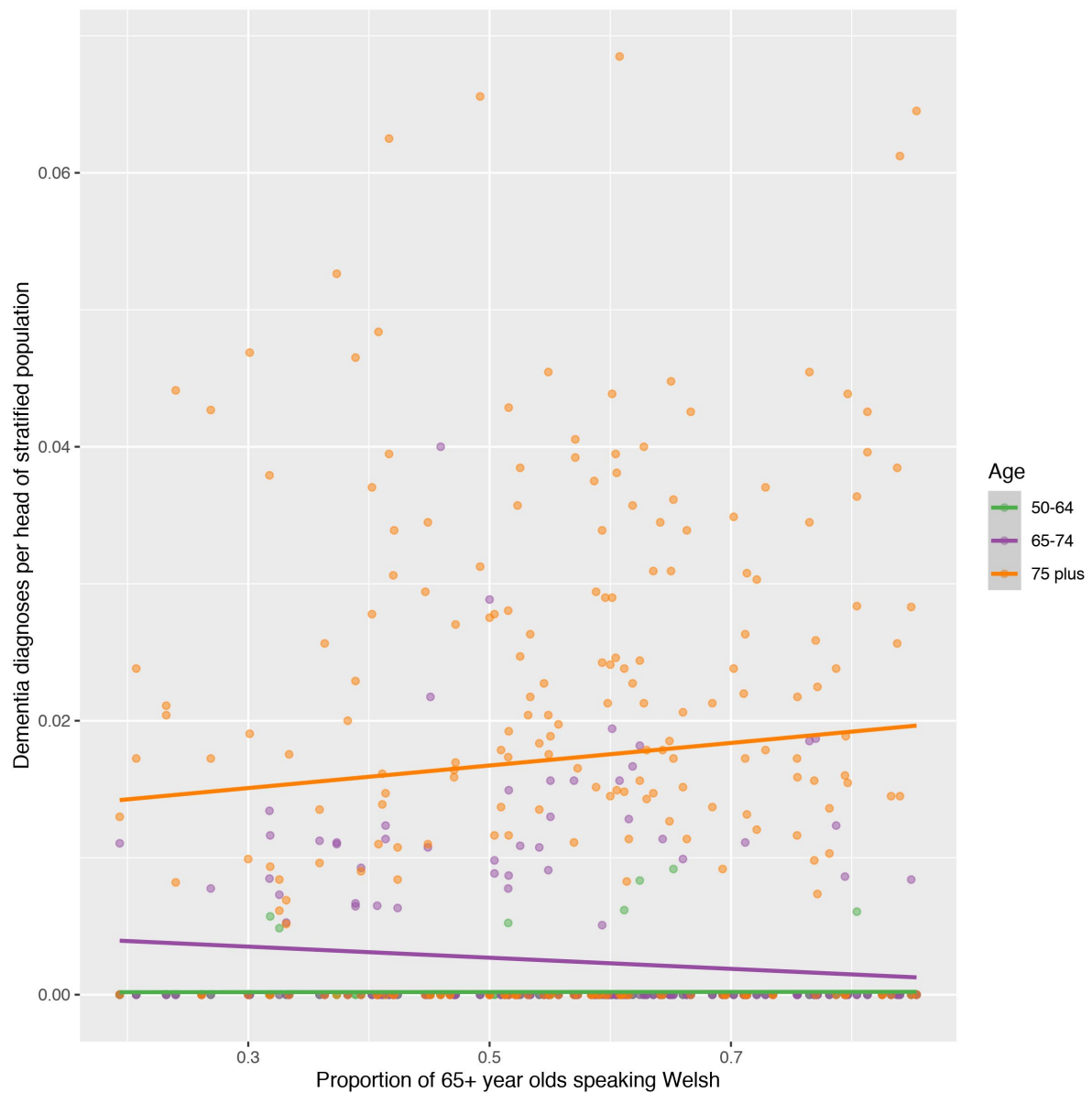

Figure 2. The association between dementia diagnosis rates and percentage speaking Welsh as a function of age band.

Table 1

Risk ratios with 95% confidence intervals for each term in the four models

	Model 1			Model 2			Model 3			Model 4		
	Estimate	2.50%	97.50%	Estimate	2.50%	97.50%	Estimate	2.50%	97.50%	Estimate	2.50%	97.50%
Proportion Welsh-speaking (z-scored)	1.021	.928	1.124	1.041	.945	1.146	1.068	.963	1.185	1.090	.982	1.209
Age 65-74	.131	.097	.177	.131	.097	.177	.121	.088	.167	.121	.088	.167
Age 50-64	.009	.004	.020	.009	.004	.020	.009	.004	.020	.009	.004	.020
Male	.836	.681	1.028	.835	.680	1.026	.838	.682	1.030	.836	.681	1.028
Percent low pay				.875	.773	.991				.874	.771	.990
Care home in LSOA	1.505	1.226	1.849	1.510	1.233	1.849	1.503	1.223	1.847	1.507	1.230	1.847
Welsh-speaking*Age 65-74							.706	.530	.939	.703	.528	.937
Welsh-speaking*Age 50-64							.806	.368	1.767	.804	.366	1.765

Table 1 displays model coefficients. A main effect of Welsh-speaking rates is not significant in any model, but in models three and four the interaction term suggests that Welsh-speaking rates are more protective in the 65-74 age-band than age 75+, the reference category. Adjusting for low-income rates (Model 4) did not change the magnitude of the interaction substantially.

Discussion

We used routinely-collected clinical administrative data to show an ecological association between rates of dementia diagnosis and Welsh-English bilingualism that varies by age. Areas with higher rates of Welsh-English bilingualism had fewer diagnoses prior to age 75, but more over the age of 75. So, although overall incidence is similar across the linguistic geography of the area, people in more Welsh-speaking areas tend to be diagnosed at an older age.

The results are consistent with delayed dementia onset in Welsh-English bilinguals, relative to English monolinguals, and contrasts with a previous study (using a different methodology) in Wales (Clare et al., 2016). Where Clare et al. focused on characterising the sample neuropsychologically and demographically, at the expense of sample size and possible sampling bias, this study used routine clinical data to maximise sample size and limit possible selection biases from participant self-selection.

The study is also consistent with previous work suggesting that the Welsh-speaking Welsh are on average healthier than both the Anglophone Welsh and English migrants to Wales, even after adjusting for socio-economic differences between groups (Saville, 2021). Later

dementia onset may be part of this broader pattern. Bilingualism is one possible mechanism for this health disparity, but these are hard to distinguish from broader cultural influences on health.

The study has important limitations. Firstly, bilingual status was not available at the individual level necessitating an ecological design. Thus results are vulnerable to the ecological fallacy. Secondly, being diagnosed older does not necessarily imply later onset. It could be that Welsh-speakers seek assessment at a later stage than English monolinguals. Neuropsychological assessment data were not available to test this. Thirdly, not all people where dementia is suspected will be seen by Memory Clinics. People are generally referred to Memory Clinics where assessment is needed. Thus, people coming to the attention of services later may be diagnosed without Memory Clinic involvement. As such, the cases analysed here represent a subset of those receiving a dementia diagnosis. Fourthly, we use Welsh-speaking rates as a proxy for bilingualism. High quality data on Welsh monolingualism do not exist; the 2011 UK census only asked about English proficiency in respondents for whom English or Welsh is not their first language. Anecdotally, Welsh-speakers who do not also speak English are extremely rare, if they exist at all. More problematically, we have not captured other forms of bilingualism. Thus, bilingualism may be understated. Finally, observational data present particular challenges for dementia research. One is competing risks: dementia may be rarer because of earlier mortality from other causes, not because of reduced risk of dementia. Given better self-rated health among Welsh speakers, compared to anglophone Welsh and English identifiers (Saville, 2021), it is possible that the apparently increased risk of dementia is due to lower mortality from other causes. Longitudinal work accounting for this is needed here.

The study also has strengths. Firstly, although other work has statistically adjusted for higher rates of bilingualism in migrants, this setting is unusual in that the non-migrants are more likely to be bilingual, so residual confounding would be in the opposite direction. Secondly, the sample uses routine clinical data, rather than relying on participants opting into research, risking selection bias. Thirdly, although there were important departures from the pre-registered protocol, pre-registration makes the analyses more transparent.

To conclude, dementia diagnosis appears to occur at older ages in areas of northwest Wales with higher rates of Welsh-English bilingualism than areas with lower rates. Although not conclusive, these results may be consistent with bilingualism delaying dementia onset.

Abraído-Lanza, A. F., Dohrenwend, B. P., Ng-Mak, D. S., & Turner, J. B. (1999). The Latino mortality paradox: A test of the 'salmon bias' and healthy migrant hypotheses. *American Journal of Public Health*, *89*(10), 1543–1548. https://doi.org/10.2105/AJPH.89.10.1543

Alladi, S., Bak, T. H., Duggirala, V., Surampudi, B., Shailaja, M., Shukla, A. K., Chaudhuri, J. R., & Kaul, S. (2013). Bilingualism delays age at onset of dementia, independent of education and immigration status. *Neurology*, *81*(22), 1938–1944. https://doi.org/10.1212/01.wnl.0000436620.33155.a4

Alladi, S., Bak, T. H., Shailaja, M., Gollahalli, D., Rajan, A., Surampudi, B., Hornberger, M., Duggirala, V., Chaudhuri, J. R., & Kaul, S. (2017). Bilingualism delays the onset of behavioral but not aphasic forms of frontotemporal dementia. *Neuropsychologia*, *99*, 207–212. https://doi.org/10.1016/j.neuropsychologia.2017.03.021

Bak, T. H., Nissan, J. J., Allerhand, M. M., & Deary, I. J. (2014). Does bilingualism influence

cognitive aging? *Annals of Neurology*, *75*(6), 959–963.

https://doi.org/10.1002/ana.24158

Bialystok, E., Craik, F. I. M., Binns, M. A., Ossher, L., & Freedman, M. (2014). Effects of

bilingualism on the age of onset and progression of MCI and AD: Evidence from

executive function tests. *Neuropsychology*, *28*(2), 290–304.

https://doi.org/10.1037/neu0000023

Bialystok, E., Craik, F. I. M., & Freedman, M. (2007). Bilingualism as a protection against the

onset of symptoms of dementia. *Neuropsychologia*, *45*(2), 459–464.

https://doi.org/10.1016/j.neuropsychologia.2006.10.009

Chertkow, H., Whitehead, V., Phillips, N., Wolfson, C., Atherton, J., & Bergman, H. (2010).

Multilingualism (But Not Always Bilingualism) Delays the Onset of Alzheimer Disease:

Evidence From a Bilingual Community. *Alzheimer Disease & Associated Disorders*,

24(2), 118–125. https://doi.org/10.1097/WAD.0b013e3181ca1221

Clare, L., Whitaker, C. J., Craik, F. I. M., Bialystok, E., Martyr, A., Martin-Forbes, P. A.,

Bastable, A. J. M., Pye, K. L., Quinn, C., Thomas, E. M., Gathercole, V. C. M., & Hindle,

J. V. (2016). Bilingualism, executive control, and age at diagnosis among people with

early-stage Alzheimer's disease in Wales. *Journal of Neuropsychology*, *10*(2), 163–

185. https://doi.org/10.1111/jnp.12061

Lawton, D. M., Gasquoine, P. G., & Weimer, A. A. (2015). Age of dementia diagnosis in

community dwelling bilingual and monolingual Hispanic Americans. *Cortex*, *66*, 141–

145. https://doi.org/doi:10.1016/j.cortex.2014.11.017.

Marmot, M. G., & Syme, S. L. (1976). Acculturation and coronary heart disease in Japanese-

Americans. *American Journal of Epidemiology*, *104*(3), 225–247.

Office for National Statistics, National Records of Scotland, & Northern Ireland Statistics and

    Research Agency. (2016). *2011 Census aggregate data. UK Data Service (Edition:*

    June 2016). http://dx.doi.org/10.5257/census/aggregate-2011-1

Perani, D., Farsad, M., Ballarini, T., Lubian, F., Malpetti, M., Fracchetti, A., Magnani, G.,

    March, A., & Abutalebi, J. (2017). The impact of bilingualism on brain reserve and

    metabolic connectivity in Alzheimer's dementia. *Proceedings of the National*

    Academy of Sciences, *114*(7), 1690–1695. https://doi.org/10.1073/pnas.1610909114

Prince, M., Bryce, R., Albanese, E., Wimo, A., Ribeiro, W., & Ferri, C. P. (2013). The global

    prevalence of dementia: A systematic review and metaanalysis. *Alzheimer's &*

    Dementia, *9*(1), 63-75.e2. https://doi.org/10.1016/j.jalz.2012.11.007

R Core Team. (2019). *R: A language and environment for statistical computing*. R Foundation

    for Statistical Computing. http://www.R-project.org/

Rousset, F., & Ferdy, J.-B. (2014). Testing environmental and genetic effects in the presence

    of spatial autocorrelation. *Ecography*, *37*(8), 781–790.

    http://dx.doi.org/10.1111/ecog.00566

Sanders, A. E., Hall, C. B., Katz, M. J., & Lipton, R. B. (2012). Non-Native Language Use and

    Risk of Incident Dementia in the Elderly. *Journal of Alzheimer's Disease*, *29*(1), 99–

    108. https://doi.org/10.3233/JAD-2011-111631

Saville, C. W. N. (2021). Health and Mental Health Disparities Between National Identity

    Groups in Wales. *Journal of Racial and Ethnic Health Disparities*.

    https://doi.org/10.1007/s40615-020-00951-z

Schweizer, T. A., Ware, J., Fischer, C. E., Craik, F. I. M., & Bialystok, E. (2012). Bilingualism as

    a contributor to cognitive reserve: Evidence from brain atrophy in Alzheimer's

    disease. *Cortex*, *48*(8), 991–996. https://doi.org/10.1016/j.cortex.2011.04.009

Stern, Y. (2002). What is cognitive reserve? Theory and research application of the reserve

concept. *Journal of the International Neuropsychological Society*, *8*(3), 448–460.

https://doi.org/10.1017/S1355617702813248

Welsh Government. (2014). *Welsh Index of Multiple Deprivation (WIMD)*.

Yeung, C. M., St. John, P. D., Menec, V., & Tyas, S. L. (2014). Is Bilingualism Associated With a

Lower Risk of Dementia in Community-living Older Adults? Cross-sectional and

Prospective Analyses. *Alzheimer Disease & Associated Disorders*, *28*(4), 326–332.

https://doi.org/10.1097/WAD.0000000000000019

Zahodne, L. B., Schofield, P. W., Farrell, M. T., Stern, Y., & Manly, J. J. (2014). Bilingualism

does not alter cognitive decline or dementia risk among Spanish-speaking

immigrants. *Neuropsychology*, *28*(2), 238–246. https://doi.org/10.1037/neu0000014