MULTIMORBIDITY AND LIFESTYLE FACTORS AMONG ADULTS WITH INTELLECTUAL DISABILITIES: A CROSS-SECTIONAL ANALYSIS OF A UK COHORT

Tyrer, Freya[1]
Dunkley, Alison J[2]
Singh, Janharpreet[2]
Kristunas, Caroline[2]
Khunti, Kamlesh[2]
Bhaumik, Sabyasachi[3]
Davies, Melanie J[2]
Yates, Thomas E[2]
Gray, Laura J[2]

1. Department of Health Sciences, University of Leicester
2. Diabetes Research Centre, University of Leicester
3. Leicestershire Partnership NHS Trust, Leicester

Corresponding author

Freya Tyrer
Department of Health Sciences, Centre for Medicine, University of Leicester, University Road, Leicester LE1 7RH
0116 252 5794
fct2@le.ac.uk

Acknowledgements

This work was funded by the National Institute for Health Research (NIHR) under the Programme Grants for Applied Research programme (RP-PG-1209-10057). Caroline Kristunas and Janharpreet Singh are funded by a NIHR Research Methods Fellowship and Internship. The authors also acknowledge support from the NIHR Collaboration for Leadership in Applied Health Research and Care – East Midlands (NIHR CLAHRC – EM) and the NIHR Leicester Biomedical Research Centre (BRC). The views expressed are those of the authors and not necessarily those of the NHS, the NIHR or the Department of Health. The STOP Diabetes study has ethics approval from East of England – Cambridge Central Research Ethics Committee (12/EE/0340).

Conflict of interest statement

KK was Chair of the National Institute for Health and Clinical Excellence (NICE) public health guidance on preventing type 2 diabetes and is adviser to the UK Department of Health for the NHS Health Checks Programme. MJD is a member of the NICE public health guidance on preventing type 2 diabetes, adviser to the national screening committee and commented on the NHS Health Checks Programme. MJD and KK have also received grants and support from the NIHR during the conduct of this study. For all other authors, no potential conflicts of interest relevant to this article are reported.

Abstract

Background

Multimorbidity (two or more conditions in addition to intellectual disability (ID)) is known to be more common among people with ID. However, the relationship between multimorbidity and lifestyle factors is currently unknown. The aim of this study was to determine the prevalence of multimorbidity in a population of adults with ID. We also aimed to identify risk factors, including lifestyle factors, for multimorbidity in this population.

Methods

This was a cross-sectional analysis using data from a diabetes screening study of 920 adults aged 18–74 years with ID living in Leicestershire, UK. We described comorbidities and the prevalence of multimorbidity in this population. We explored the relationship between multimorbidity and age, gender, ethnicity, severity of ID, socioeconomic status, physical activity, sedentary behaviour, fruit and vegetable consumption and smoking status using multiple logistic regression.

Results

The prevalence of multimorbidity was 61.2% (95% CI 57.7–64.7). Multimorbidity was independently associated with being female ($p<0.001$) and severe/profound ID ($p=0.004$). Increasing age was of borderline significance ($p=0.06$). Individuals who were physically inactive or sedentary were more likely to be multimorbid, independent of ability to walk, age, gender, severity of ID, ethnicity and socioeconomic status (adjusted OR=1.91; 95% CI 1.23–2.97; $p=0.004$ and OR=1.98; 95% CI 1.42–2.77; $p<0.001$). After excluding probable life-long conditions (autism spectrum conditions, attention deficit hyperactivity disorders, epilepsy, cerebral palsy and other paralytic syndromes) as contributing comorbidities, the effect of sedentary behaviour, but not physical activity, remained ($p=0.004$). We did not observe a relationship between multimorbidity, fruit and vegetable consumption or smoking status.

Conclusions

Multimorbidity presents a significant burden to people with ID. Individuals who were physically inactive or sedentary were more likely to be multimorbid but further work is recommended to explore the relationship between multimorbidity and lifestyle factors using standardised objective measures.

Keywords

Multimorbidity

Intellectual disability

Lifestyle

Sedentary behaviour

Introduction

Multimorbidity is defined as two or more chronic conditions in the same individual (Van den Akker *et al.* 1996). It has a prevalence of between 12.9% and 95.1%, depending on case definition and populations studied, and has fairly consistently been found to be associated with increasing age, lower socioeconomic status and female gender in the general population (Violan *et al.* 2014). A relationship between multimorbidity and ethnicity has also been observed in some populations, with a higher prevalence generally found among some minority ethnic populations (Mathur *et al.* 2011, Ahmadi *et al.* 2016, Johnson-Lawrence *et al.* 2017).

Among people with intellectual disabilities (ID), multimorbidity has typically been defined as two or more chronic conditions in addition to ID (McCarron *et al.* 2013, Hermans and Evenhuis 2014, Cooper *et al.* 2015). People with ID are additionally disadvantaged with regard to multimorbidity because they often have more physical and/or mental health problems than the rest of the population (Cooper and van der Speck 2009, Krahn and Fox 2014). Despite this, there is very little research on multimorbidity in the ID population. Evidence so far suggests that the prevalence of two or more chronic conditions in addition to ID is 40.6% among adults with ID (Cooper *et al.* 2015) and between 71% and 80% among older adults with ID (McCarron *et al.* 2013, Hermans and Evenhuis 2014). Higher prevalence of multimorbidity has been reported in women (McCarron et al. 2013, Cooper et al. 2015), older individuals with ID (McCarron et al. 2013, Cooper et al. 2015, Hermans and Evenhuis 2014) and among people with severe/profound ID (Hermans and Evenhuis 2014).

Knowledge about multimorbidity in people with ID is important for health care and resource planning. Multimorbidity is associated with more complex clinical management (Crentsil *et al.* 2010), higher health care utilisation and costs (Glynn *et al.* 2011, Naessens *et al.* 2011, Salisbury *et al.* 2011, Schoenberg *et al.* 2007), higher health care needs (Laux *et al.* 2008, Fung *et al.* 2008) and health-related quality of life (Loza *et al.* 2009, Fortin *et al.* 2007). It is also a risk factor for frailty (Fried *et al.* 2001), which occurs earlier in people with ID than the general population (Evenhuis *et al.* 2012) and is associated with hospitalisation and death (Fried et al. 2001).

With an ageing population, it is important to consider potentially modifiable risk factors for multimorbidity so that preventive strategies can be tested. Thus far, the limited evidence available suggests that there may be an association between lifestyle factors and multimorbidity in the general population. Previous research has found a relationship between lower consumption of fruit and vegetables (Ruel *et al.* 2014), physical inactivity (Ahmadi et al. 2016, Dhalwani *et al.* 2016), sedentary behaviour (Loprinzi 2015) and former smoking (Chung *et al.* 2015, Ahmadi et al. 2016). An association between overweight and obesity (lifestyle indicators) with multimorbidity has also been observed (Booth *et al.* 2014, Ahmadi et al. 2016).

The primary purpose of this study was to determine the prevalence of multimorbidity in adults with ID. We also aimed to identify risk factors, including lifestyle factors, for multimorbidity in adults with ID.

Methods

This study involved a cross-sectional analysis of the 'STOP Diabetes' cohort. The STOP Diabetes study, including full details of data collection, has been described elsewhere (Dunkley *et al.* 2017a, Dunkley *et al.* 2017b) but, briefly, involved a population-based screening programme of adults (aged 18–74 years) with ID in Leicestershire, UK. Participants were recruited between December 2012 and September 2015 from general practices and specialist ID services. The study involved the collection of anthropometric measures (height, weight, blood pressure), blood samples and additional demographic and lifestyle data. The case record form included collection of data on chronic conditions that were perceived to be clinically important to adults with ID (with corresponding International Classification of Diseases (ICD-10) (World Health Organization 1992) system codes). This information was collected directly from the participants and/or carers by research nurses as part of the screening process, using additional information from the participant's Health Action Plan (Department of Health 2002) and medical records review. Additional conditions were coded as individual ICD-10 codes. Adults were excluded from screening for the STOP Diabetes study if they had existing type 1 or type 2 diabetes, life-limiting terminal illness or systemic disease interfering with measurement and interpretation of glycated haemoglobin (HbA1c) levels. Therefore, the population comprised adults with ID who did not have diabetes.

Definition of multimorbidity

For the purpose of this analysis, multimorbidity was defined as two or more chronic conditions in addition to ID. Initially, 19 chronic conditions were included in this definition based on their perceived clinical importance and to align with previous research in this area (Cooper et al. 2015). These conditions were: viral hepatitis; malignant neoplasms; hypothyroidism; dementia; mental health disorders; epilepsy; migraine; cerebral palsy and

other paralytic syndromes; hypertension; ischaemic heart disease; cerebrovascular disease; other heart disease; chronic respiratory diseases; digestive system diseases; dermatitis/eczema; arthritis/gout; osteopathies/chondropathies; renal failure; and dysphagia. Obesity was included as a comorbidity because of its conceptual relationship with lifestyle and because it is treated as a chronic condition in some countries (e.g. USA (American Medical Association 2007)). We defined this as a clinical diagnosis of obesity (ICD-10 code E66), BMI≥30 for white ethnicity, or BMI≥27.5 for non-white ethnicity to align with guidance from the National Institute for Health and Clinical Excellence (NICE) (National Institute for Health and Clinical Excellence (NICE) 2014).

Given its high prevalence and significant burden on carers in this population, we also reported on the prevalence of challenging behaviours in this population, but we have not included this in our definition of multimorbidity owing to its established relationship with mental ill-health (Allen 2008). In addition, we did not include congenital or genetic disorders linked with ID, such as Down syndrome. Owing to difficulties in confirming diagnoses, some health problems reported by participants, such as sensory impairment were not included in the coding.

In addition and to align with our intention to identify potential modifiable lifestyle factors contributing to multimorbidity, we also explored a refined definition of multimorbidity which excluded comorbidities likely to have been present from birth or early childhood: these were autism spectrum disorders (ASD; F84), attention-deficit hyperactivity disorders (ADHD; F90), epilepsy (G40) and cerebral palsy or other paralytic syndromes (G80–G83).

Lifestyle measures

The STOP diabetes study included the collection of information on physical activity, sedentary behaviour, fruit/vegetable intake and smoking status. Targets on physical activity, sedentary behaviour and fruit/vegetable intake were aligned with UK and World Health Organisation (WHO) guidance (Food Standards Agency 2010, World Health Organisation 2013, World Health Organisation 2010, Department of Health 2011). Based on participant/carers reported outcomes, it was assumed that doing any sports, exercise or physical activity 5 or more times per week would meet recommendations to do a minimum of 150 minutes of moderate intensity activity or 75 minutes of vigorous activity. Outcomes were thus dichotomised into: 5 or more times per week; and <5 times per week. Similarly, for data collected on how often participants sat during the day, a report of sometimes or never was assumed to meet the guidance to 'minimise the amount of time spend sedentary (sitting) for extended periods' (Department of Health 2011). For fruit and vegetable intake, responses were divided into: 5 or more portions per day; and less than 5 per day. Data were not available on more than 7 portions so we could not test the efficacy of 10 or more portions per day, as recommended in a recent systematic review (Aune *et al.* 2017).

We also included information on socioeconomic status using indices of multiple deprivation deciles. Indices of multiple deprivation provide statistics on relative deprivation, based on geographical location (postcode), and are scored from 1 (for the 10% most deprived neighbourhoods in the country) to 10 (for the least deprived neighbourhoods in the country) (Department of Communities and Local Government 2010). We also used data collected on individuals' severity of ID using clinical diagnoses (from medical records) based on ICD-10 codes: F70 (mild); F71 (moderate); F72 (severe); and F73 (profound).

Analyses

Demographic characteristics, lifestyle factors, ability to walk independently and the prevalence of the health conditions were described. The relationship between multimorbidity, age, gender, ethnicity, area of multiple deprivation decile and ID severity was explored using multiple logistic regression modelling using likelihood ratio tests to evaluate subgroup characteristics. The relationship between multimorbidity and physical activity, sedentary behaviour, fruit/vegetable consumption and smoking was investigated using separate logistic regression models (also adjusting for the effects of age, gender, ethnicity, area of multiple deprivation and ID severity). The analyses were repeated using our revised multimorbidity definition (to exclude ASD, ADHD, epilepsy, cerebral palsy and other paralytic syndromes). When exploring the relationship between multimorbidity, physical activity and sedentary behaviour, we also adjusted for ability to walk. Multicollinearity (i.e. high correlations) between the predictor variables was tested using correlation matrices and the variation inflation factor (VIF). Interactions by subgroups were tested using likelihood ratio tests. All analyses were carried out in Stata version 14 (StataCorp 2015).

Results

In total, 920 participants with ID were initially investigated, after excluding one individual who did not have any data on their health conditions and nine individuals who were found to have (previously undiagnosed) type 2 diabetes mellitus when screened. The characteristics of the participants are shown in Table 1. Just over half (58%) were male, mean age was 42.9 years and 67.5% were obese or overweight. Most of the adults lived alone or with family (n=382; 41.5%), in residential accommodation (n=349; 37.9%) or in shared housing/supported living accommodation (n=157; 17.1%).

233 [Table 1 about here]

234

235 The most common health problems in addition to ID were mental ill-health (43.0%), obesity
236 (31.0%), epilepsy (28.4%) and dysphagia (24.9%). Among the 787 individuals for whom data
237 on all comorbidities were available, 86 participants (10.9%) had none of the conditions
238 reported, 219 (27.8%) had one, 256 (31.3%) had two and 236 (30.0%) had three or more
239 conditions. The prevalence of two or more conditions in addition to ID (our working definition
240 of multimorbidity) was 61.2% (95% CI 57.7–64.7); this was more prevalent among women
241 (68.6% vs 56.0%; p<0.001) and older age groups (72.9% [60–74 years] vs 57.1% [18–29
242 years]; chi^2 p=0.002). Mental ill-health and obesity (15.1%), followed by mental ill-health and
243 epilepsy (10.8%) and mental ill-health and dysphagia (9.5%), were the most frequently
244 occurring comorbidities (in addition to ID).

245

246 Figure 1 shows the relationship between multimorbidity and common risk factors reported in
247 the general population, after adjustment for age, gender, ethnicity, area of multiple
248 deprivation and severity of ID. Female gender was associated with increased prevalence of
249 multimorbidity (p<0.001). Similarly, people with severe/profound ID had higher odds of
250 multimorbidity compared with those with mild ID (adjusted OR=1.95; 95% CI 1.31–2.89;
251 p=0.004). There was a general trend towards increased multimorbidity with increasing age
252 but this did not reach statistical significance (p=0.06). We found no effect of socioeconomic
253 status on multimorbidity (p=0.18). We also did not find any significant interactions between
254 the variables or evidence of multicollinearity (all VIFs<2).

255

256 [Figure 1 about here]

257

Figure 2 shows the relationship between multimorbidity and lifestyle factors. After adjustment for ability to walk and the risk factors outlined in Figure 1, an association was found between multimorbidity and participants who did sports, exercise or physical activity <5 times per week (OR=1.91; 95% CI 1.23–2.97; p=0.004). We also found a relationship between multimorbidity and adults who were sedentary (i.e. sat for 'a lot', most or all of the day) (OR=1.98; 95% CI 1.42–2.77; p<0.001). We found no effect of fruit and vegetable consumption or smoking on multimorbidity.

[Figure 2 about here]

On excluding ASD, ADHD, epilepsy, cerebral palsy and other paralytic syndromes from our working definition of multimorbidity (n=363 for those with ≥2 comorbidities remaining), the effect of physical activity was no longer statistically significant (p=0.16) but the effect of sedentary behaviour remained (p=0.006).

Discussion

Our findings show that multimorbidity is highly prevalent among people with ID and is a particular concern for younger adults; 61.2% of all adults and 57.1% of those aged 18–29 years in our population had at least two conditions. We found that both physical inactivity and sedentary behaviour were associated with increased odds of having multimorbidity. We found the effect of sedentary behaviour persisted, even after excluding conditions likely to have been present from birth or early childhood.

To our knowledge, this is the first time that the relationship between multimorbidity and lifestyle factors has been investigated in an ID population. Our findings of a relationship between multimorbidity, sedentary behaviour and physical activity is important for health and social care planning because there is scope to develop interventions to modify physical activity and, in particular, sedentary levels to potentially reduce multimorbidity and its associated health care costs, utilisation and needs (Crentsil et al. 2010, Glynn et al. 2011, Naessens et al. 2011, Salisbury et al. 2011, Schoenberg et al. 2007, Laux et al. 2008, Fung et al. 2008). In line with global policy initiatives that focus on positive wellbeing in the ID population (World Health Organisation 2011), there is also the potential to improve health-related quality of life, which is associated with multimorbidity (Loza et al. 2009, Fortin et al. 2007). Previous literature in the general population suggests that people who are more physically active have lower rates of multimorbidity (Ahmadi et al. 2016, Dhalwani et al. 2016). There is also increasing evidence that sedentary behaviour, independent of physical inactivity, is associated with multimorbidity (Loprinzi 2015, Owen *et al.* 2010). However, we are unable to report on the direction of the associations seen in this cross-sectional study. Sedentary behaviour and physical inactivity are known to be relatively common among people with ID (Dairo *et al.* 2016, Melville *et al.* 2017), and are likely to be more prevalent among those with co-existing chronic conditions. It is noteworthy that the effect of sedentary behaviour remained, even after excluding those conditions likely to have been present before initiating any changes in lifestyle behaviours. Although individuals' lifestyle choices are clearly linked to their own health and wellbeing, the finding that mental ill-health, epilepsy (when included) and dysphagia were the most common contributors to multimorbidity in our cohort suggests that imposed sedentary and inactive lifestyles due to ill-health do not fully explain our findings and deserves further investigation.

Consistent with previous research in the ID population, we found that female gender (Cooper et al. 2015) and severe/profound ID (Hermans and Evenhuis 2014) were associated with multimorbidity. We found that mental ill-health dominated across all subgroups. However, further investigation revealed that women generally had more mental health-related comorbidities than men (19.5% vs 12.0% for mental ill-health/obesity; 12.2% vs 9.8% for mental ill-health/epilepsy; and 10.4% vs 7.0% for mental ill-health/digestive system diseases]). Similarly, dysphagia and digestive system diseases featured more highly among people with severe/profound ID than those with mild ID (12.8% vs 2.9% for dysphagia/digestive system diseases and 11.5% vs 7.9% for dysphagia/mental ill-health). We found a lesser effect of increasing age on multimorbidity, possibly because multimorbidity was so prevalent in the younger age groups. However, whereas obesity and mental ill-health were the most common contributors to multimorbidity in younger individuals (22.3% for those aged 18–29 compared with 11.2% in those aged 60–74), the older individuals had a higher proportion of dysphagia and mental ill-health (16.8% vs 8.2%). In line with Cooper et al.'s (2015) study, we also did not find an effect of socioeconomic status on multimorbidity in the ID population, and a similar proportion of adults in our study population resided in the most deprived two postcode deciles (21.1% compared with Cooper et al's study of 25.8%). It has been hypothesised that this may reflect their greater likelihood of living in deprived areas (Cooper *et al.* 2011, Morgan *et al.* 2000). The lack of effect may also reflect the location of residential and supported living accommodation which is not dependent on socioeconomic status.

Although comparisons with the general population are restricted, given that the case definition of multimorbidity varies substantially between studies, we are able to draw some broad comparisons between our population and other general population and ID studies. We

found that the prevalence of multimorbidity was substantially high in the younger age groups with ID: 57.1% among 18–29 year olds, compared with around 4% of a comparable age range (18–34 years old) in the general population (Salisbury et al. 2011). Multimorbidity may be seen at an earlier age because of the neurodevelopmental consequences of brain damage, such as epilepsy (Arvio and Sillanpaa 2003), and earlier onset of comorbidities in people with genetic conditions, such as hypothyroidism in people with Down syndrome (Lott 2012). This is supported by our finding that the rates of epilepsy were particularly high in our ID population (28.4%), much higher than the rates found in the general population (0.8%) (Cooper et al. 2015). Similarly, the rate of arthritis/gout, often a factor in studies of multimorbidity in the general population (Lowe *et al.* 2017, Schram *et al.* 2008) was low. There was also an absence of conditions related to alcohol dependence, which is a feature of other general population multimorbidity studies (McLean *et al.* 2014).

Limitations

A key limitation of this research is that we did not use objective measurements of physical activity and sedentary time which affects reproducibility of the findings and may have introduced bias. A recent systematic review of physical activity levels in the adult ID population (16–81 years found that 9% of participants in the studies achieved the equivalent of physical activity guidelines of 150 minutes moderate to vigorous physical activity per week (Dairo et al. 2016). We found that 13.6% of adults in our population reported doing sports, exercise or physical activity 5 or more times per week but we do not know how this equates to minutes. We also recognise that it is unlikely that people with profound ID and mobility problems in our cohort could achieve the recommended physical activity thresholds. Similarly, we found that 46.7% of adults in our population were sedentary for ‘a lot’, most or all of the day, compared with recent systematic review evidence using objectively

(accelerometer) measured sedentary behaviour of 63%–87.5% (Melville et al. 2017). Our measures were measured by proxy at a single point-in-time and we did not assess the reliability and validity of our assessment methods. We therefore recommend more research in this area using objective measures.

In addition, people with diabetes were excluded from the eligible population; it is recognised that cardiometabolic conditions are common contributors to multimorbidity (Prazeres and Santiago 2015, Violan et al. 2014) and that people with ID may be particularly vulnerable to such conditions because of the metabolic effects of long-term antipsychotic drug use (de Kuijper *et al.* 2013). Similarly, we also excluded a small number of adults with life-limiting illness or systemic disease interfering with measurement and interpretation of HbA1c levels. Therefore, we have underestimated the extent of multimorbidity in the adult ID population, which further highlights its importance.

Conclusions

We have shown high rates of multimorbidity in an adult ID population and that younger age groups are particularly disadvantaged. Strategies to reduce multimorbidity should focus on people with ID of all ages regardless of their socioeconomic status and consider common conditions that contribute to multimorbidity prevalence and are potentially preventable, such as mental ill-health. We recommend further work to explore the relationship between multimorbidity, physical activity, sedentary behaviour and other lifestyle variables using validated objective measures in this population.

References

Ahmadi, B., Alimohammadian, M., Yaseri, M., Majidi, A., Boreiri, M., Islami, F., Poustchi, H., Derakhshan, M. H., Feizesani, A., Pourshams, A., Abnet, C. C., Brennan, P., Dawsey, S. M., Kamangar, F., Boffetta, P., Sadjadi, A. & Malekzadeh, R. (2016) Multimorbidity: Epidemiology and Risk Factors in the Golestan Cohort Study, Iran: A Cross-Sectional Analysis. Medicine, 95, e2756.

Allen, D. (2008) The relationship between challenging behaviour and mental ill-health in people with intellectual disabilities: a review of current theories and evidence. Journal of Intellectual Disabilities, 12, 267-294.

American Medical Association (2007) Report on the Council on Science and Public Health. American Medical Association, Chicago, IL.

Arvio, M. & Sillanpaa, M. (2003) Prevalence, aetiology and comorbidity of severe and profound intellectual disability in Finland. J Intellect Disabil Res, 47, 108-12.

Aune, D., Giovannucci, E., Boffetta, P., Fadnes, L. T., Keum, N., Norat, T., Greenwood, D. C., Riboli, E., Vatten, L. J. & Tonstad, S. (2017) Fruit and vegetable intake and the risk of cardiovascular disease, total cancer and all-cause mortality-a systematic review and dose-response meta-analysis of prospective studies. International Journal of Epidemiology, 22, 22.

Booth, H. P., Prevost, A. T. & Gulliford, M. C. (2014) Impact of body mass index on prevalence of multimorbidity in primary care: cohort study. Family Practice, 31, 38-43.

Chung, R. Y., Mercer, S., Lai, F. T. T., Yip, B. H. K., Wong, M. C. S. & Wong , S. Y. S. (2015) Socioeconomic Determinants of Multimorbidity: A Population-Based Household Survey of Hong Kong Chinese. PloS ONE, 10, e0140040.

Cooper, S. A., McConnachie, A., Allan, L. M., Melville, C., Smiley, E. & Morrison, J. (2011) Neighbourhood deprivation, health inequalities and service access by adults with

406 intellectual disabilities: a cross-sectional study. Journal of Intellectual Disability
407 Research, 55, 313-23.
408 Cooper, S. A., McLean, G., Guthrie, B., McConnachie, A., Mercer, S., Sullivan, F. &
409 Morrison, J. (2015) Multiple physical and mental health comorbidity in adults with
410 intellectual disabilities: population-based cross-sectional analysis. BMC Family
411 Practice, 16, 110.
412 Cooper, S. A. & van der Speck, R. (2009) Epidemiology of mental ill health in adults with
413 intellectual disabilities. Current Opinion in Psychiatry, 22, 431-6.
414 Crentsil, V., Ricks, M. O., Xue, Q. L. & Fried, L. P. (2010) A pharmacoepidemiologic study of
415 community-dwelling, disabled older women: Factors associated with medication use.
416 American Journal of Geriatric Pharmacotherapy 8, 215-224.
417 Dairo, Y. M., Collett, J., Dawes, H. & Oskrochi, G. R. (2016) Physical activity levels in adults
418 with intellectual disabilities: A systematic review. Prev Med Rep, 4, 209-19.
419 de Kuijper, G., Mulder, H., Evenhuis, H., Scholte, F., Visser, F. & Hoekstra, P. J. (2013)
420 Determinants of physical health parameters in individuals with intellectual disability
421 who use long-term antipsychotics. Res Dev Disabil, 34, 2799-809.
422 Department of Communities and Local Government (2010) Indices of multiple deprivation.
423 The Stationery Office, London.
424 Department of Health (2002) Action for Health - Health Action Plans and Health Facilitators.
425 Department of Health, London.
426 Department of Health (2011) Start active, stay active: a report on physical activity from the
427 four home countries' chief medical officers. Department of Health, London.
428 Dhalwani, N. N., O'Donovan, G., Zaccardi, F., Hamer, M., Yates, T., Davies, M. & Khunti, K.
429 (2016) Long terms trends of multimorbidity and association with physical activity in

older English population. International Journal of Behavioral Nutrition & Physical Activity, 13, 8.

Dunkley, A. J., Tyrer, F., Spong, R., Gray, L. J., Gillett, M., Doherty, Y., Martin-Stacey, L., Patel, N., Yates, T., Bhaumik, S., Chalk, T., Chudasama, Y., Thomas, C., Sadler, S., Cooper, S.-A., Gangadharan, S. K., Davies, M. J. & Khunti, K. (2017a) Screening for glucose intolerance and development of a lifestyle education programme for prevention of Type 2 diabetes in a population with intellectual disabilities. Programme Grants for Applied Research, 5, doi: 10.3310/pgfar05110.

Dunkley A.,J., Tyrer, F., Gray, L. J., Bhaumik, S., Spong, R., Chudasama, Y., Cooper, S-A., Ganghadaran, S.K., Davies, M.J., Khunti, K. (2017b). Type 2 diabetes and glucose intolerance in a population with intellectual disabilities: the STOP diabetes cross-sectional screening study. Journal of Intellectual Disability Research, 61, 668–81.

Evenhuis, H. M., Hermans, H., Hilgenkamp, T. I., Bastiaanse, L. P. & Echteld, M. A. (2012) Frailty and disability in older adults with intellectual disabilities: results from the healthy ageing and intellectual disability study. Journal of the American Geriatrics Society, 60, 934-8.

Food Standards Agency (2010) Eat Well: your guide to healthy eating. Food Standards Agency, London.

Fortin, M., Dubois, M. F., Hudon, C., Soubhi, H. & Almirall, J. (2007) Multimorbidity and quality of life: a closer look. Health & Quality of Life Outcomes, 5, 52.

Fried, L. P., Tangen, C. M., Walston, J., Newman, A. B., Hirsch, C., Gottdiener, J., Seeman, T., Tracy, R., Kop, W. J., Burke, G., McBurnie, M. A. & Cardiovascular Health Study Collaborative Research, G. (2001) Frailty in older adults: evidence for a phenotype. Journals of Gerontology Series A-Biological Sciences & Medical Sciences, 56, M146-56.

Fung, C. H., Setodji, C. M., Kung, F. Y., Keesey, J., Asch, S. M., Adams, J. & McGlynn, E. A. (2008) The relationship between multimorbidity and patients' ratings of communication. Journal of General Internal Medicine, 23, 788-93.

Glynn, L. G., Valderas, J. M., Healy, P., Burke, E., Newell, J., Gillespie, P. & Murphy, A. W. (2011) The prevalence of multimorbidity in primary care and its effect on health care utilization and cost. Family Practice, 28, 516-23.

Hermans, H. & Evenhuis, H. M. (2014) Multimorbidity in older adults with intellectual disabilities. Research in Developmental Disabilities, 35, 776-83.

Johnson-Lawrence, V., Zajacovab, A. & Sneed, R. (2017) Education, race/ethnicity, and multimorbidity among adults aged 30–64 in the National Health Interview Survey. SSM Population Health, 3, 366-372.

Krahn, G. L. & Fox, M. H. (2014) Health disparities of adults with intellectual disabilities: what do we know? What do we do? Journal of Applied Research in Intellectual Disabilities, 27, 431-46.

Laux, G., Kuehlein, T., Rosemann, T. & Szecsenyi, J. (2008) Co- and multimorbidity patterns in primary care based on episodes of care: results from the German CONTENT project. BMC Health Services Research, 8, 14.

Loprinzi, P. D. (2015) Sedentary behavior and medical multimorbidity. Physiology & Behavior, 151, 395-7.

Lott, I. T. (2012) Neurological phenotypes for Down syndrome across the life span. Preventive Medicine Reports, 197, 101-121.

Lowe, D. B., Taylor, M. J. & Hill, S. J. (2017) Cross-sectional examination of musculoskeletal conditions and multimorbidity: influence of different thresholds and definitions on prevalence and association estimates. BMC Research Notes, 10, 51.

Loza, E., Jover, J. A., Rodriguez, L., Carmona, L. & Group, E. S. (2009) Multimorbidity: prevalence, effect on quality of life and daily functioning, and variation of this effect when one condition is a rheumatic disease. Seminars in Arthritis & Rheumatism, 38, 312-9.

Mathur, R., Hull, S. A., Badrick, E. & Robson, J. (2011) Cardiovascular multimorbidity: the effect of ethnicity on prevalence and risk factor management. British Journal of General Practice, 61, e262-e270.

McCarron, M., Swinburne, J., Burke, E., McGlinchey, E., Carroll, R. & McCallion, P. (2013) Patterns of multimorbidity in an older population of persons with an intellectual disability: results from the intellectual disability supplement to the Irish longitudinal study on aging (IDS-TILDA). Research in Developmental Disabilities, 34, 521-7.

McLean, G., Gunn, J., Wyke, S., Guthrie, B., Watt, G. C., Blane, D. N. & Mercer, S. W. (2014) The influence of socioeconomic deprivation on multimorbidity at different ages: a cross-sectional study. British Journal of General Practice, 64, e440-7.

Melville, C. A., Oppewal, A., Liselotte Schäfer, E., Freiberger, E., Guerra-Balic, M., Hilgenkamp, T. I. M., Einarsson, I., Izquierdo-Gómez, R. H., Sansano-Nadal, O., Rintala, P., Cuesta-Vargas, A. & Giné-Garriga, M. (2017) Definitions, measurement and prevalence of sedentary behaviour in adults with intellectual disabilities — A systematic review. Preventive Medicine, 97, 62-71.

Morgan, C. L., Ahmed, Z. & Kerr, M. P. (2000) Health care provision for people with a learning disability. Record-linkage study of epidemiology and factors contributing to hospital care uptake. British Journal of Psychiatry, 176, 37-41.

Naessens, J. M., Stroebel, R. J., Finnie, D. M., Shah, N. D., Wagie, A. E., Litchy, W. J., Killinger, P. J., O'Byrne, T. J., Wood, D. L. & Nesse, R. E. (2011) Effect of multiple

503 chronic conditions among working-age adults. American Journal of Managed Care, 17,
504 118-22.
505 National Institute for Health and Clinical Excellence (NICE) (2014) Body mass index
506 thresholds for intervening to prevent ill health among black, Asian and other minority
507 ethnic groups [Online]. Available from: http://www.thehealthwell.info/node/709954
508 [Accessed: 12th October 2017].
509 Owen, N., Sparling, P. B., Healy, G. N., Dunstan, D. W. & Matthews, C. E. (2010) Sedentary
510 behavior: Emerging evidence for a new health risk. Mayo Clinic Proceedings, 85,
511 1138-1141.
512 Prazeres, F. & Santiago, L. (2015) Prevalence of multimorbidity in the adult population
513 attending primary care in Portugal: a cross-sectional study. BMJ Open, 5, e009287.
514 Ruel, G., Shi, Z., Zhen, S., Zuo, H., Kroger, E., Sirois, C., Levesque, J. F. & Taylor, A. W.
515 (2014) Association between nutrition and the evolution of multimorbidity: the
516 importance of fruits and vegetables and whole grain products. Clinical Nutrition, 33,
517 513-20.
518 Salisbury, C., Johnson, L., Purdy, S., Valderas, J. M. & Montgomery, A. A. (2011)
519 Epidemiology and impact of multimorbidity in primary care: a retrospective cohort
520 study. British Journal of General Practice, 61, e12-21.
521 Schoenberg, N. E., Kim, H., Edwards, W. & Fleming, S. T. (2007) Burden of common
522 multiple-morbidity constellations on out-of-pocket medical expenditures among older
523 adults. Gerontologist, 47, 423-37.
524 Schram, M. T., Frijters, D., van de Lisdonk, E. H., Ploemacher, J., de Craen, A. J., de Waal,
525 M. W., van Rooij, F. J., Heeringa, J., Hofman, A., Deeg, D. J. & Schellevis, F. G.
526 (2008) Setting and registry characteristics affect the prevalence and nature of
527 multimorbidity in the elderly. Journal of Clinical Epidemiology, 61, 1104-12.

StataCorp (2015) Stata Statistical Software: Release 14. Statacorp LP, College Station, TX.

Van den Akker, M., Buntinx, F. & Knottnerus, J. A. (1996) Comorbidity or multimorbidity: What's in a name? A review of literature. European Journal of General Practice 2, 65-70.

Violan, C., Foguet-Boreu, Q., Flores-Mateo, G., Salisbury, C., Blom, J., Freitag, M., Glynn, L., Muth, C. & Valderas, J. M. (2014) Prevalence, determinants and patterns of multimorbidity in primary care: a systematic review of observational studies. PLoS ONE [Electronic Resource], 9, e102149.

World Health Organisation (2010) Global recommendations on physical activity for health. World Health Organisation, Geneva.

World Health Organisation (2011) World report on disability. World Health Organization, Geneva.

World Health Organisation (2013) Global action plan for the prevention and control of noncommunicable diseases 2013–2020. World Health Organisation, Geneva.

World Health Organization (1992) The international classification of diseases 10th revision. World Health Organization, Geneva.

Tables

Table 1: Demographic characteristics of participants with ID

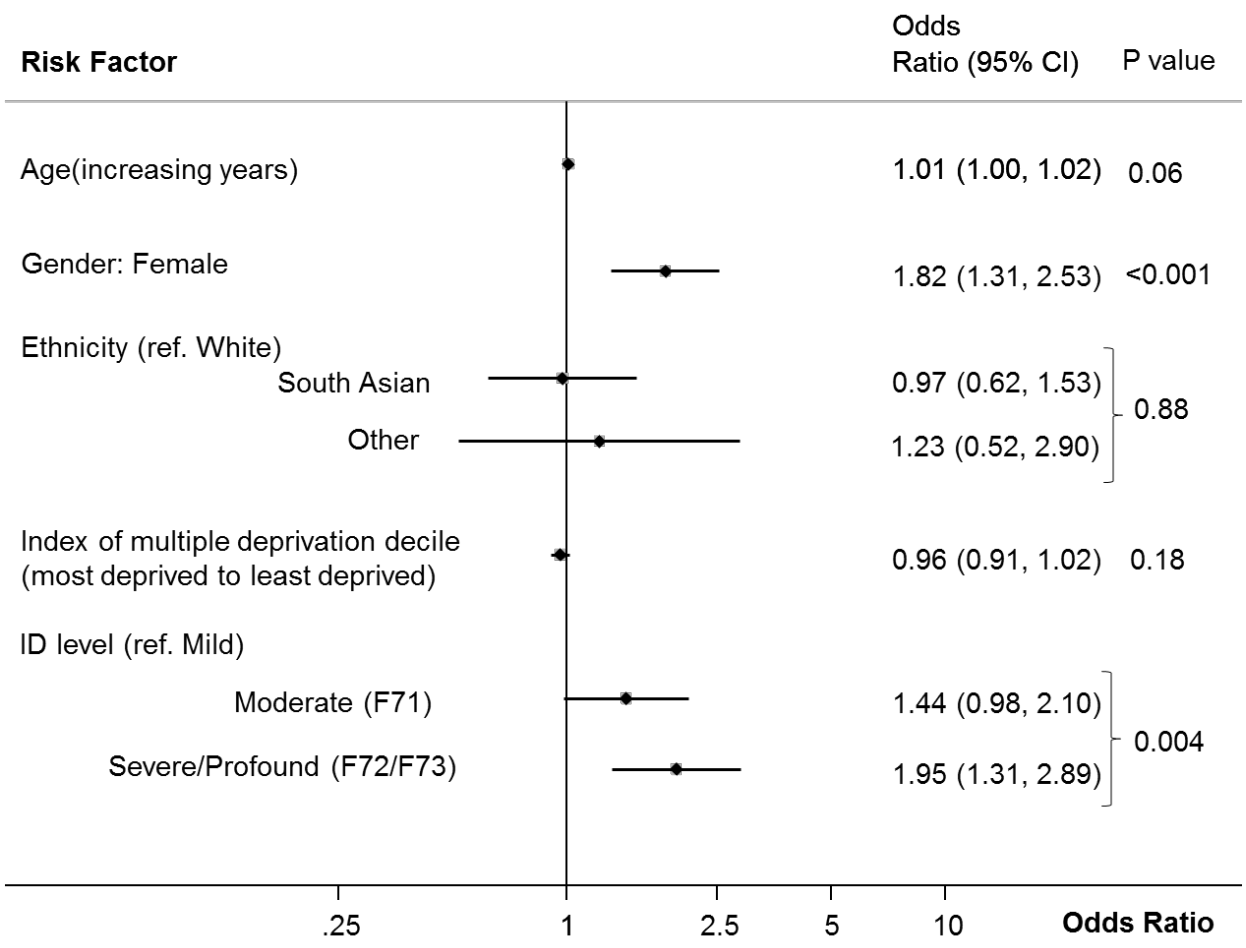
Participant characteristic	Number/Mean	(% / range)
Gender (n=920)		
Male	530	(57.6)
Female	390	(42.4)
Age (n=920)	42.9	(18–74)
Ethnicity (n=920)		
White	747	(81.2)
South Asian	141	(15.3)
Black African/Caribbean	13	(1.4)
Mixed	12	(1.3)
Other	7	(0.8)
ID severity (ICD-10) (n=809)		
Mild (F70)	259	(31.6)
Moderate (F71)	243	(30.0)
Severe/Profound (F72/F73)	310	(38.3)
Living status/Accommodation (n=920)		
Alone	50	(5.4)
With family	332	(36.1)
Residential/nursing home	349	(37.9)
Shared housing/supported living	157	(17.1)
Other	32	(3.5)
Area of multiple deprivation decile (n=920)		
[1=least deprived; 10=most deprived]	5.3	(1–10)
Sports, exercise or physical activity (n=919)		
5 or more times per week	125	(13.6)
< 5 times per week	794	(86.4)
Sitting down (sedentary behaviour; n=919)		
Never/sometimes sits during the day	490	(53.3)
Sits down for all, most or ‘a lot’ of the day	429	(46.7)

Fruit and vegetable consumption (n=911)		
5 or more portions per week	268	(29.4)
< 5 portions per week	648	(70.6)
Smoking (n=920)		
Never	806	(87.6)
Ex-regular smoker	38	(4.1)
Current regular smoker	76	(8.3)
Ability to walk (n=919)		
Without assistance	781	(85.0)
With assistance	83	(9.0)
Not able to walk	55	(6.0)
Health conditions (ICD-10 code); n=920		
Viral Hepatitis (B15 – B19)	3	0.3
Malignant neoplasms (C00 – C96)	6	0.7
Hypothyroidism (E00 – E03)	91	9.9
Obesity (E66)*	307	33.4
Dementia (F00 – F03)	19	2.1
Mental health disorder (F04 – F69**, F84, F90, F93, F95)	396	43.0
Challenging behaviours †	128	13.9
Epilepsy (G40)	261	28.4
Migraine (G43)	7	0.8
Cerebral palsy & other paralytic syndromes (G80 – G83)	63	6.9
Hypertension (I10)	62	6.7
Ischaemic heart disease (I20 – I25)	7	0.8
Cerebrovascular disease (I60 – I69)	13	1.4
Other heart disease (I26 – I28,I34 – I39, I48, I70 – I89, Z95)	32	3.5
Chronic respiratory diseases (J40 – J47)	88	9.6
Digestive system diseases (K00 – K93) ‡	201	21.9

Dermatitis and eczema (L20 – L30)	23	2.5
Arthritis and Gout (M05 – M19)	26	2.8
Osteopathies and chondropathies (M80 – M94)	14	1.5
Renal failure (N17 – N19)	7	0.8
Dysphagia (R20)	228	24.9

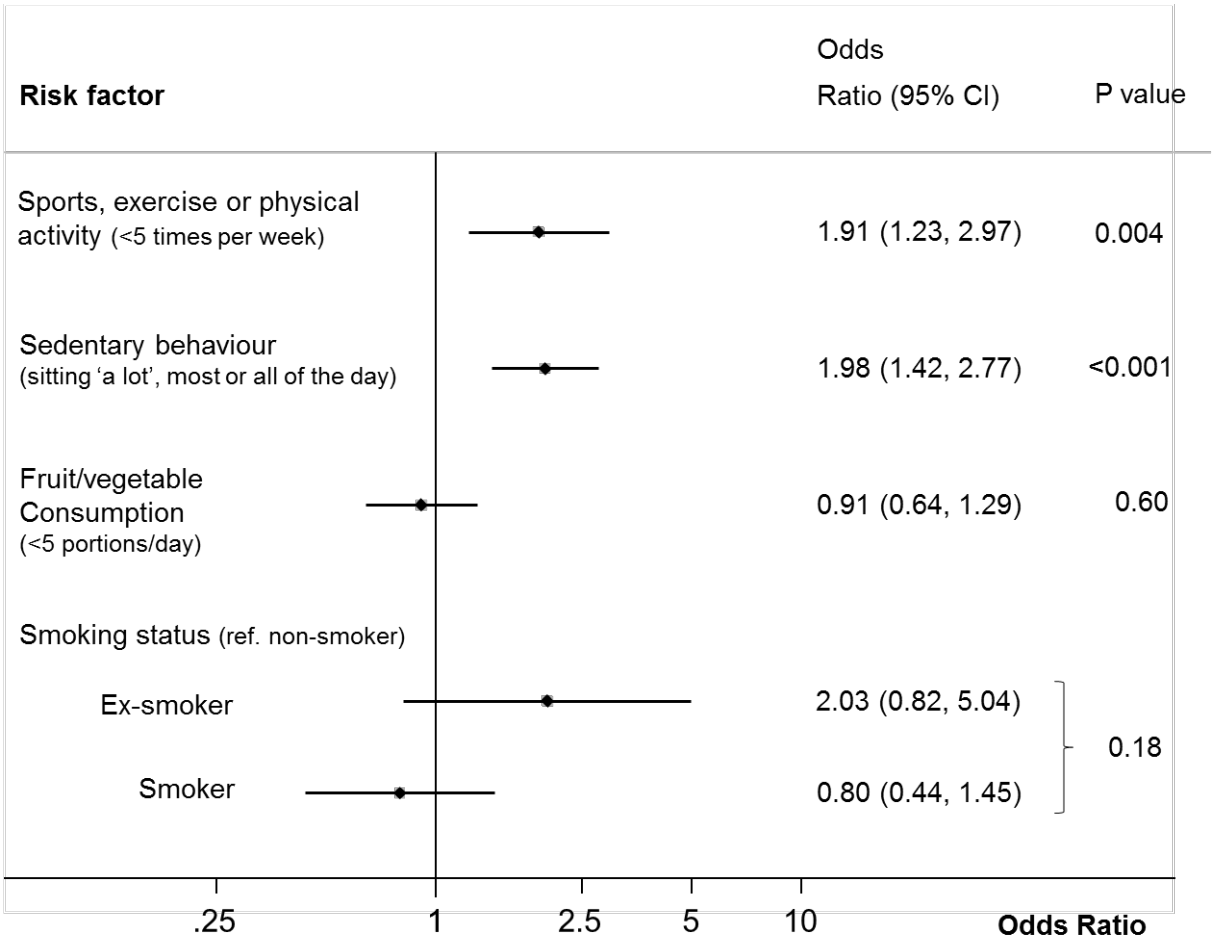
548 * n=787 with data available. Obesity defined as BMI≥30 (white ethnicity), BMI≥27.5 (non-white
549 ethnicity) and/or ICD-10 diagnosis of obesity
550 ** acute occurrences were excluded from the multimorbidity definition for mental health disorders–
551 depressive episode (F32), manic episode (F30) – and phobic anxiety disorder (F40)
552 † not included in multimorbidity definition for analysis;
553 ‡ 76% taking gastro-intestinal medication
554
555

Figure 1: Relationship between multimorbidity, age, gender, ethnicity, socioeconomic status and severity of intellectual disability* (n=687)



* adjusted for all other variables in model

Figure 2: Relationship between multimorbidity and lifestyle factors*



* n=687 for sedentary behaviour and smoking status; n=686 for sports, exercise, physical activity; n=684 for fruit/vegetable consumption; adjusted for gender, age, ethnicity, severity of ID and index of multiple deprivation

† also adjusted for ability to walk