Contribution of chronic diseases to disability in elderly people in countries with low and middle incomes: a 10/66 Dementia Research Group population-based survey

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Summary

Background Disability in elderly people in countries with low and middle incomes is little studied; according to Global Burden of Disease estimates, visual impairment is the leading contributor to years lived with disability in this population. We aimed to assess the contribution of physical, mental, and cognitive chronic diseases to disability, and the extent to which sociodemographic and health characteristics account for geographical variation in disability.

Methods We undertook cross-sectional surveys of residents aged older than 65 years (n=15 022) in 11 sites in seven countries with low and middle incomes (China, India, Cuba, Dominican Republic, Venezuela, Mexico, and Peru). Disability was assessed with the 12-item WHO disability assessment schedule 2.0. Dementia, depression, hypertension, and chronic obstructive pulmonary disease were ascertained by clinical assessment; diabetes, stroke, and heart disease by self-reported diagnosis; and sensory, gastrointestinal, skin, limb, and arthritic disorders by self-reported impairment. Independent contributions to disability scores were assessed by zero-inflated negative binomial regression and Poisson regression to generate population-attributable prevalence fractions (PAPF).

Findings In regions other than rural India and Venezuela, dementia made the largest contribution to disability (median PAPF 25·1% [IQR 19·2–43·6]). Other substantial contributors were stroke (11·4% [1·8–21·4]), limb impairment (10·5% [5·7–33·8]), arthritis (9·9% [3·2–34·8]), depression (8·3% [0·5–23·0]), eyesight problems (6·8% [1·7–17·6]), and gastrointestinal impairments (6·5% [0·3–23·1]). Associations with chronic diseases accounted for around two-thirds of prevalent disability. When zero inflation was taken into account, between-site differences in disability scores were largely attributable to compositional differences in health and sociodemographic characteristics.

Interpretation On the basis of empirical research, dementia, not blindness, is overwhelmingly the most important independent contributor to disability for elderly people in countries with low and middle incomes. Chronic diseases of the brain and mind deserve increased prioritisation. Besides disability, they lead to dependency and present stressful, complex, long-term challenges to carers. Societal costs are enormous.

Introduction

WHO's International Classification of Functioning, Disability and Health[1] defines disability as "the negative aspects of the interaction between an individual (with a health condition) and that individual's contextual factors (personal and environmental factors)". Interactions are specified as including impairments (affecting the body), activity limitations (affecting actions or behaviour), and participation restrictions (affecting experience of life). According to the Global Burden of Disease[2] estimates for 2004, 68% of the 751 million years lived with disability (YLD) worldwide are attributable to chronic non-communicable diseases, and 84% of this burden of chronic-disease disability arises in countries with low and middle incomes.

Although the prevalence and incidence of most chronic diseases are strongly age dependent, only 23% of the disability burden caused by chronic disease in countries with low and middle incomes occurs in people aged 60 years and older, compared with 36% for high-income countries, where demographic ageing is much more advanced. However, chronic-disease disability in elderly people in countries with low and middle incomes is set to increase sharply. Between 2010 and 2050, the number of people aged 60 years and older will increase by 56% in most developed regions (from 269 million to 416 million, or from 21·8% to 32·6% of the total population), but by 224% in least developed regions (from 490 million to 1·59 billion, or from 8·6% to 20·2% of the total population). The accompanying epidemiological transition will greatly increase the burden of chronic non-communicable diseases, especially in the most rapidly developing regions.[3]

According to the Global Burden of Disease report,[2] the five leading contributors to YLD in elderly people in low-income and middle-income countries are eye

diseases, hearing loss, dementia, musculoskeletal diseases, and heart disease. Contributions of health problems to YLD are determined by their incidence, duration, and a disorder-specific disability weight. Disability weights were established by an international panel of health professionals using an iterative person trade-off approach, and represent implicit societal preferences for particular health states. This approach has two main limitations. First, other than in the Global Burden of Disease report,[2] inference of disability from diagnoses is not usual practice; it conflicts with the contextually interactive notion of disability that is outlined by the International Classification of Functioning, Disability and Health.[1]

Second, many elderly people often have several disease comorbidities; the Global Burden of Disease investigators aspire to divide disability into components that are independently attributable to different health problems, but the straightforward additive approach that is used is, by Murray and Lopez's[4] admission, oversimplistic and flawed. They provide two main justifications for this approach.[4] The first is the low availability of population surveys of health and functioning—this limitation applies especially to elderly people in countries with low and middle incomes, since most comprehensive studies have focused on young and middle-aged adults.[5–7] The second is the absence of a straightforward and widely used measure with a universal metric that is capable of assessing disability across regions, cultures, and disorders.

A new instrument, the WHO disability assessment schedule (WHODAS) 2.0,[8] was developed in parallel with the International Classification of Functioning, Disability and Health.[1] Equal attention was given to its conceptual basis (consistent with the International Classification) and to its psychometric robustness. A key aim was to identify the consequences of any type of health problem, treating all disorders at parity in assessing levels of function.[9] Psychometric testing has been rigorous. An early draft (89 items) was tested in field trials in 21 sites and 19 countries to ensure cross-cultural applicability. On the basis of psychometric analyses and further field testing, the measure was shortened to 36 items, and a 12-item screening questionnaire was developed.[10]

In the 10/66 Dementia Research Group's population-based surveys in India, China, and five countries in Latin America, WHODAS 2.0 was administered to nearly 15 000 elderly people. Initial analyses of these data have established that WHODAS 2.0 is a unidimensional scale, conforming to principles of the item response theory, and meeting formal criteria for measurement invariance across the many countries, languages, and cultures represented.[11] Participants were also assessed comprehensively for chronic-disease diagnoses and impairments. We have used these data to assess first, the independent contribution of physical, mental, and cognitive chronic diseases to disability scores across the 10/66 population-based studies, comparing our findings with those of the Global Burden of Disease report,[2] and second, the extent to which compositional factors (sociodemographic variables and health states) might account for geographical variation in disability scores.

Methods

Participants

One-phase population-based surveys were undertaken, between 2003 and 2005, of all elderly people (aged 65 years and older) living in geographically defined catchment areas from seven developing countries (urban sites in Cuba, Dominican Republic, and Venezuela, and urban and rural sites in Mexico, Peru, China, and India). The protocol for the baseline survey[12] consists of a wide-ranging participant interview, a structured clinical interview, an informant interview, and a physical examination. Information is obtained about socio-demographic characteristics, health status, disability, risk factors, anthropometry, health-service use, care arrangements, and carer strain. We describe in detail only the assessments that are relevant to the present analyses. The sample size for each country was between 2000 and 3000. All studies were approved by local ethical committees and by the King's College London research ethics committee.

Procedures

Disability was measured with the 12-item WHODAS 2.0. This short version of the WHODAS 2.0 covers all six domains of the full 36-item version. Correlation with the 36-item version of WHODAS 2.0 was 0·95.[10] The schedule has five activity-limitation domains: understanding or communication, getting around (mobility), self-care, getting along with people (interpersonal interaction), and life activities. A sixth domain, participation in society, assesses broad social aspects of disability. Each domain is covered by two questions, with scores ranging from 0 (no difficulty) to 4 (extreme difficulty or cannot do). The standardised global score ranges from 0 (non-disabled) to 100 (maximum disability). WHODAS 2.0 has high internal consistency, moderate to good test–retest reliability, and good concurrent validity in many clinical populations with chronic disease.[9,13–20]

We assessed the psychometric properties of the 12-item interviewer-administered WHODAS 2.0 in the 10/66 Dementia Research Group population-based survey samples.[11] Strong internal consistency and high factor loadings for the one-factor solution showed unidimensionality. Furthermore, WHODAS 2.0 conformed to a strong Mokken scale in all sites. Measurement invariance was substantiated by comparison of confirmatory factor analysis models in which factor loadings were constrained or freely estimated across sites, and by the high between-site correlations in item difficulties.

Information about age, sex, marital status, educational attainment (defined as: none; some, not completed primary; completed primary; and completed secondary or tertiary) and living circumstances were assessed with a standard sociodemographic questionnaire. The ascertainment of previous episodes of stroke or ischaemic heart disease was based on self-report ("have you ever been told by a doctor that you had a stroke/angina/heart attack?"). Stroke was coded only if there was a clear history of sudden onset of unilateral paralysis, loss of speech, or blindness lasting for more than 24 h, hence excluding previous episodes of transient ischaemic attack. Dementia was ascertained according to the cross-culturally validated 10/66 dementia diagnosis algorithm[21] and the Diagnostic and Statistical Manual of Mental Disorders IV dementia criterion[22,23] after extensive multidomain cognitive testing and clinical and informant interview. A full account is provided in our report describing prevalence of dementia in baseline survey samples.[24]

Depression according to 10th International Classification of Diseases criteria was ascertained with the structured geriatric mental state clinical interview.[25] Hypertension was determined according to European Society of Hypertension criteria (systolic blood pressure ≥140 mm Hg or diastolic blood pressure ≥95 mm Hg) or a positive answer to the question "have you ever been told by a doctor that you have hypertension?". Chronic obstructive pulmonary disease (COPD) was diagnosed in people who responded "yes" to the question "do you usually cough up phlegm from your chest first thing in the morning?" and whose answer to the question "for how many months of the year does this usually happen?" was 3 months or more. Diabetes was ascertained by a positive answer to the question "have you ever been told you had diabetes?".

Physical impairments were assessed on the basis of self-reported paralysis, weakness, or loss of a limb; eyesight problems; stomach or intestine problems; arthritis or rheumatism; heart problems; hearing difficulties or deafness; breathlessness; difficulty in breathing or asthma; fainting or blackouts; skin disorders, such as pressure sores, leg ulcers, or severe burns; or persistent cough. Impairments were rated as present if they interfered with activities "a little" or "a lot", as opposed to "not at all".[26]

Statistical analysis

We used Stata 10.0 for all statistical analyses, using the 10/66 Dementia Research Group data release 2.0, with robust standard errors, adjusted for household clustering. For all sites, we describe the sociodemographic characteristics of the sample, the prevalence of chronic-disease diagnoses and impairments, mean WHODAS 2.0 global disability scores and standard deviations, the proportion with WHODAS 2.0 scores of zero, and the mean of non-zero scores.

We then modelled effect of site on WHODAS 2.0 scores using zero-inflated negative binomial regression (ZINB). This approach deals with overdispersion and zero-inflation, allowing for excess zeros in count models under the assumption that the population is characterised by two groups, one in which members always have zero counts, and one in which members have zero or positive counts. The likelihood of being a certain zero is estimated with a logit specification, and counts in the second group are estimated with a negative binomial specification. The first model included the effect of site only, fitting dummy variables for site for the zero inflation and negative binomial count parts of the model. The second model also included effects of age, sex, educational attainment, marital status, and all chronic-disease diagnoses and impairments. The aim was to compare the effect of site before and after adjustment for these compositional variables. We also checked the appropriateness of the ZINB model compared with negative binomial, using the Vuong test (which has a standard normal distribution in which large positive values favour the ZINB model and large negative values favour the negative binomial model), and a likelihood-ratio test comparing the ZINB model with zero-inflated Poisson.

Next, we generated ZINB models, separately for each site, to estimate the independent associations of health disorders with disability, controlling for age, sex, education, and marital status. After fitting the ZINB model separately by site we used a fixed-effects meta-analysis to combine them, estimating degree of heterogeneity using Higgins' I^2 with approximate 95% CIs.[27] We then fitted the same models using a Poisson regression working model with the 90th centile of the WHODAS 2.0 distribution in each site as a threshold; although somewhat arbitrary, this approach has been recommended for modelling of WHODAS 2.0 scores as a dichotomised outcome.[28] The aim was to calculate a population-attributable prevalence fraction (PAPF) for the association between each disorder and high disability scores and a total PAPF for their combined effect, with the Stata aflogit command. Stata aflogit estimates the individual and combined attributable fractions robustly from within the Poisson regression framework. PAPFs, when calculated from prevalence ratios in cross-sectional studies, represent the proportion of prevalent severe disability that could theoretically be avoided if the exposure could be removed from the population, with effect of exposure on both incidence and duration of the severe disability state taken into account and the assumption of causal relations estimated free of confounding.

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The sponsors of the study had no role in study design, data collection, data analysis, data interpretation, or writing of the report. All authors had full access to all the data in the study, and the corresponding author had final responsibility for the decision to submit for publication.

	Cuba (n=2937)	Dominican Republic (n=2001)	Urban Peru (n=1380)	Rural Peru (n=552)	Venezuela (n=1947)	Urban Mexico (n=1002)	Rural Mexico (n=1000)	Urban China (n=1160)	Rural China (n=1002)	Urban India (n=1001)	Rural India (n=999)
Health disorders											
Hypertension	72·9% (71·3–74·6)	75·4% (73·4–77·3)	52·3% (49·6–54·9)	41·3% (37·2–45·5)	72·1% (70·0–74·0)	67·1% (64·2–69·9)	54·4% (51·3–57·6)	62·6% (59·8–65·3)	49·9% (46·5–53·3)	59·5% (56·4–62·6)	28·5% (25·7–31·4)
Eyesight problems	29·3% (27·6–31·0)	39·6% (37·4–41·8)	32·9% (30·4–35·5)	35·6% (31·4–39·7)	39·6% (37·3–41·9)	28·4% (25·5–31·3)	35·7% (32·6–38·8)	16·7% (14·5–18·9)	6·5% (4·8–8·1)	8·8% (7·1–10·6)	22·1% (19·6–24·6)
Arthritis or rheumatism	21·5% (19·9–23·1)	36·7% (34·6–38·8)	15·3% (13·4–17·3)	6·7% (4·6–8·8)	24·3% (22·3–26·4)	14·5% (12·3–16·8)	14·2% (19·7–24·9)	14·2% (12·2–16·3)	1·9% (1·1–2·8)	18·2% (15·7–20·5)	51·1% (47·9–54·2)
Diabetes	15·8% (17·1–19·9)	14·0% (12·4–15·5)	8·7% (7·2–10·2)	9·8% (7·3–12·3)	16·2% (14·4–17·7)	24·5% (21·9–27·2)	18·9% (16·4–21·4)	16·8% (14·7–18·9)	1·0% (0·3–1·5)	12·1% (10·0–14·1)	6·6% (5·0–8·2)
Hearing difficulties	9·9% (8·9–11·01)	12·7% (11·2–14·2)	21·6% (19·4–23·8)	15·8% (12·6–18·9)	14·5% (12·9–16·1)	19·7% (17·2–22·3)	22·9% (20·3–25·5)	12·3% (10·3–14·2)	8·6% (6·8–10·4)	3·1% (1·9–4·2)	14·2% (12·1–16·4)
Dementia	10·9% (9·8–12·1)	12·0% (10·6–13·5)	9·4% (7·7–11·1)	6·5% (4·5–8·6)	7·4% (6·2–8·5)	9·3% (7·4–11·1)	8·7% (6·9–10·5)	7·3% (5·7–8·7)	5·6% (4·2–7·0)	7·5% (5·8–9·2)	10·8% (8·8–12·8)
Stroke	7·8% (6·8–8·8)	8·7% (7·5–9·9)	8·2% (6·7–9·6)	3·6% (2·1–5·2)	7·1% (5·8–8·2)	6·7% (5·2–8·2)	7·4% (5·7–9·1)	9·4% (7·7–11·1)	1·8% (0·9–2·6)	1·9% (1·1–2·8)	1·1% (0·4–1·7)
Stomach or intestine problems	8·7% (7·7–9·8)	19·3% (17·6–21·1)	17·6% (15·5–19·7)	5·8% (3·8–7·7)	18·8% (17·1–20·7)	12·6% (10·6–14·7)	17·5% (15·2–19·9)	5·7% (4·4–7·2)	1·2% (0·5–1·8)	2·3% (1·4–3·2)	5·0% (3·6–6·4)
Heart problems	8·1% (7·2–9·1)	4·6% (3·7–5·5)	3·9% (2·8–4·9)	2·5% (1·2–3·8)	9·6% (8·3–10·9)	3·9% (2·7–5·1)	2·3% (1·4–3·2)	28·4% (25·7–31·0)	3·1% (2·1–4·2)	1·8% (0·9–2·6)	0·5% (0·1–0·9)
Myocardial infarction or angina	14·2% (12·8–15·4)	2·9% (2·3–3·7)	6·6% (5·2–7·9)	4·4% (2·7–6·1)	6·2% (5·1–7·3)	3·8% (2·7–5·1)	1·5% (0·7–2·3)	9·9% (8·2–11·7)	1·2% (0·5–1·8)	4·8% (3·5–6·3)	2·8% (1·7–3·8)
Difficulty breathing or asthma	7·1% (6·1–7·9)	9·5% (8·2–10·8)	4·9% (3·7–6·1)	4·2% (2·5–5·8)	9·1% (7·7–10·3)	5·3% (3·9–6·6)	5·4% (3·9–6·8)	4·5% (3·3–5·6)	1·9% (1·1–2·7)	5·7% (4·3–7·1)	10·7% (8·8–12·6)
Depression	4·9% (4·1–5·7)	13·8% (12·3–15·4)	6·3% (4·9–7·6)	2·9% (1·5–4·3)	5·4% (4·5–6·4)	4·7% (3·4–5·9)	4·5% (3·2–5·8)	0·3% (0·0–0·5)	0·7% (0·2–1·2)	3·8% (2·5–5·1)	12·6% (10·5–14·7)
Paralysis or weakness of limb(s)	2·8% (2·2–3·4)	5·1% (4·2–6·1)	3·2% (2·2–4·1)	1·3% (0·3–2·2)	9·1% (7·7–10·3)	3·4% (2·3–4·5)	2·5% (1·5–3·5)	6·2% (4·8–7·6)	4·4% (3·2–5·6)	1·5% (0·7–2·3)	2·6% (1·6–3·6)
Persistent cough	1·7% (1·2–2·2)	10·3% (8·9–11·6)	4·5% (3·4–5·6)	2·4% (1·1–3·6)	8·8% (7·5–10·2)	5·8% (4·4–7·2)	4·4% (3·2–5·6)	2·8% (1·9–3·8)	13·9% (0·6–2·2)	2·8% (1·8–3·9)	6·7% (5·2–8·3)
COPD	3·9% (3·2–4·6)	6·8% (5·7–7·9)	5·9% (4·6–7·2)	1·9% (0·8–3·2)	6·7% (5·6–7·9)	5·8% (4·4–7·3)	8·0% (6·3–9·6)	3·1% (2·1–4·1)	1·6% (0·8–2·4)	1·8% (0·9–2·6)	7·6% (5·9–9·3)
Skin disorders	1·2% (0·7–1·5)	1·9% (1·4–2·5)	7·2% (5·8–8·6)	1·5% (0·5–2·5)	3·9% (3·1–4·8)	3·4% (2·3–4·5)	3·6% (2·5–4·7)	1·1% (0·5–1·6)	0·2% (0·0–0·5)	0·9% (0·3–1·5)	3·2% (2·1–4·3)
Fainting or blackouts	1·1% (0·6–1·4)	3·5% (2·7–4·4)	1·7% (0·9–2·4)	0·9% (0·1–1·7)	3·9% (3·1–4·7)	0·5% (0·1–0·9)	1·8% (0·9–2·6)	5·4% (4·1–6·7)	0·9% (0·4–1·6)	1·5% (0·7–2·3)	10·5% (8·6–12·4)
WHODAS 2.0											
Mean scores (SD)	13·4 (20·0)	16·5 (20·3)	13·0 (20·6)	10·4 (14·5)	10·7 (16·4)	10·0 (17·3)	11·1 (19·1)	8·1 (20·1)	8·0 (14·5)	10·5 (15·4)	28·3 (18·3)
Zero scores (%)	37·8%	31·4%	40·4%	33·6%	41·4%	48·3%	51·3%	75·7%	56·4%	47·7%	2·3%
Mean scores (SD) omitting zeros	21·5 (21·7)	24·0 (20·5)	21·9 (22·7)	15·7 (15·4)	18·3 (17·8)	19·3 (19·9)	22·7 (22·0)	33·2 (28·9)	18·7 (17·2)	16·9 (16·6)	28·9 (17·9)

Data are percentage (95% CI), unless otherwise stated. COPD=chronic obstructive pulmonary disease. WHODAS=WHO disability assessment schedule.

Table 1: **Prevalence of health disorders and mean WHODAS 2.0 scores by site**

Results

15 022 interviews were completed in 11 sites in seven countries. Response proportions varied between 72% and 98%, and were 80% or higher in all but two sites (urban China and urban India).[24] WHODAS 2.0 disability assessments were completed for 14 869 participants (99%). The webappendix shows distribution of sociodemographic characteristics by site. Mean age of the participants varied between 71·3 and 75·2 years, and was higher in Latin America and urban China than in rural China and India. Women accounted for between 53% and 66% of participants by site. Educational

attainment was highest in Cuba and urban Peru (only 3% having no education) and Venezuela (8%). In the Dominican Republic, rural Peru, and Mexico, 15–33% did not have any education, and in rural China (58%) and rural (66%) and urban India (43%) having no education was the mode. Pension coverage was especially low in the Dominican Republic, rural Peru, rural Mexico, rural China, and India; food insecurity was prevalent in these sites.

Table 1 shows the prevalence of diagnoses and self-reported impairments by site. The most common self-reported impairments were eyesight problems (median

prevalence 28·4% [IQR 6·5–39·6]), arthritis or rheumatism (18·2% [1·9–51·1]), hearing difficulties (14·2% [3·1–22·9]), and gastrointestinal problems (8·7% [1·2–19·3]). Paralysis or weakness of limbs, heart problems, difficulty in breathing or asthma, fainting or blackouts, skin disorders, and persistent cough were reported by fewer than 10% of participants, for almost all sites. The most common diagnosis was hypertension (median prevalence 62·6% [28·5–75·4]), followed by diabetes (14·0% [1·0–24·5]), dementia (8·7% [5·6–12·0]), stroke (7·1% [1·1–8·7]), COPD (5·8% [1·6–7·6]), depression (4·7% [0·3–13·8]), and ischaemic heart disease (4·4% [1·2–14·2]).

Distribution of WHODAS 2.0 scores varied greatly between sites. Most of the variation was accounted for by two sites: urban China, with a high proportion of zero scores (75·7%) and hence a low mean score, and rural India, with a very low proportion (2·3%) of zero scores and hence a high mean score. The first ZINB model (table 2) assessed effect of site on WHODAS 2.0 disability scores. This model showed that most of the between-site variation arose from zero inflation, which was most pronounced in China (particularly urban China) and least evident in rural India. The between-site variation that was estimated in the negative binomial count part of the model was small, and (with the exception of rural India) diminished after adjustment for compositional differences between sites in chronic disease, age, sex, education, and marital status. However, between-site variation in zero inflation was not reduced after adjustment for these variables. For this final model, ZINB fitted better than did negative binomial (Vuong test, z=76·5, p<0·0001, suggesting substantial zero inflation) or zero-inflated Poisson models (α=0·52 [95% CI 0·50–0·54], χ^2=62000, p<0·0001, showing substantial overdispersion).

Table 3 shows independent associations between health disorders and WHODAS 2.0 disability score counts from the ZINB models, listed in order of effect size (pooled meta-analysed relative risk [RR]). The largest effect sizes and most consistently significant associations across sites were recorded for dementia, paralysis or weakness of a limb, depression, stroke, and arthritis or rheumatism. All effects in the model were significant after pooled meta-analysis other than those for myocardial infarction or angina, COPD, and hypertension. However, heterogeneity was severe (I^2>56%) for dementia, paralysis or weakness of a limb, depression, skin disorders, eyesight problems, and myocardial infarction or angina. Patterns of heterogeneity varied between disorders, and closer inspection did not reveal any obvious source.

We calculated PAPFs from a Poisson regression working model, using the 90th centile of the WHODAS 2.0 score in each site as a threshold to identify severe disability (table 4). In every site other than rural India and Venezuela, dementia made the largest contribution to severe disability. Other substantial contributors were

	Crude model	Adjusted model*
Zero inflation		
Cuba	1†	..
Dominican Republic	0·75 (0·66–0·86)	1·08 (0·93–1·26)
Peru (urban)	1·12 (0·97–1·30)	1·10 (0·93–1·28)
Peru (rural)	0·79 (0·64–0·99)	0·57 (0·45–0·73)
Venezuela	1·16 (1·02–1·32)	1·24 (1·07–1·44)
Mexico (urban)	1·55 (1·33–1·81)	1·67 (1·39–2·00)
Mexico (rural)	1·78 (1·53–2·07)	2·16 (1·79–2·60)
China (urban)	5·42 (4·57–6·36)	6·89 (5·70–8·33)
China (rural)	2·26 (1·93–2·65)	1·37 (1·13–1·66)
India (urban)	0·97 (0·83–1·14)	0·64 (0·53–0·77)
India (rural)	0·01 (0·00–0·11)	0·02 (0·01–0·05)
Count		
Cuba	1†	..
Dominican Republic	1·12 (1·05–1·20)	1·01 (0·95–1·07)
Peru (urban)	1·02 (0·93–1·11)	1·03 (0·96–1·11)
Peru (rural)	0·72 (0·64–0·81)	0·96 (0·87–1·06)
Venezuela	0·84 (0·78–0·91)	0·86 (0·80–0·91)
Mexico (urban)	0·89 (0·80–0·99)	0·97 (0·88–1·07)
Mexico (rural)	1·06 (0·96–1·17)	1·14 (1·03–1·25)
China (urban)	1·56 (1·39–1·76)	1·27 (1·14–1·41)
China (rural)	0·87 (0·78–0·96)	1·14 (1·05–1·23)
India (urban)	0·78 (0·71–0·86)	1·09 (1·00–1·19)
India (rural)	1·36 (1·27–1·44)	1·65 (1·55–1·77)

Data for zero inflation are odds ratio (95% CI); data for count are ratio of counts (95% CI). WHODAS=WHO disability assessment schedule. *Adjusted for age, sex, educational attainment, marital status, and all chronic-disease diagnoses and impairments. †Reference.

Table 2: **Between-site variation in zero inflation and WHODAS 2.0 score counts as modelled by zero-inflated negative binomial regression, before and after adjustment for compositional factors**

stroke, paralysis or weakness of limbs, arthritis or rheumatism, depression, eyesight problems, and stomach or intestine problems. Although the PAPF for hypertension was substantial in several sites, none of the underlying associations were significant. In rural Peru, which was the site with the smallest sample, chronic-disease impairments and diagnoses were collectively associated with a PAPF of 40·1%. Across all other sites, total PAPF ranged from 61·8% to 74·5%.

Discussion
WHO's Global Burden of Disease report provides important evidence for the relative effects of health disorders worldwide,[2,29] affecting prioritisation for policy making and planning nationally, regionally, and internationally. However, the rank ordering of the contributions of chronic diseases to disability that were noted in this report differ in important respects from those estimated from results of the 10/66 population-based surveys (table 5). In our studies, dementia is overwhelmingly and consistently the largest contributor to disability. Sensory impairment, both of eyesight and

hearing, and heart disease contributed much less to disability than was suggested by the Global Burden of Disease estimates. According to our findings, stroke and arthritis merit a high ranking, especially since some of the effect of limb paralysis or weakness (with a median PAPF of 10·5%) almost certainly arises from these two diagnoses, which could well have been under-reported in our surveys.

Zero-inflated negative binomial regression was the most appropriate statistical method for modelling of

	Cuba	DR	Urban Peru	Rural Peru	Venezuela	Urban Mexico	Rural Mexico	Urban China	Rural China	Urban India	Rural India	Meta-analysed RR (95% CI)	Q value	I² value (95% CI)
Dementia	2·44 (2·19–2·71)	1·57 (1·38–1·78)	2·66 (2·25–3·15)	2·03 (1·52–2·71)	1·99 (1·67–2·39)	1·72 (1·27–2·31)	2·03 (1·61–2·56)	2·15 (1·78–2·60)	1·86 (1·55–2·24)	1·85 (1·52–2·27)	1·32 (1·18–1·47)	1·88 (1·79–1·98)	93·6	89% (83–93)
Paralysis or weakness of limb(s)	1·96 (1·67–2·29)	1·91 (1·68–2·15)	1·48 (1·07–2·05)	1·46 (0·94–2·27)*	1·38 (1·21–1·59)	1·31 (0·97–1·75)*	1·86 (1·24–2·78)	2·34 (1·76–3·11)	2·11 (1·69–2·64)	2·62 (1·88–3·64)	1·53 (1·21–1·94)	1·76 (1·65–1·87)	34·1	71% (46–84)
Depression	1·62 (1·42–1·84)	1·42 (1·29–1·56)	1·45 (1·19–1·75)	1·86 (1·21–2·86)	1·58 (1·33–1·89)	1·39 (1·09–1·77)	1·51 (1·21–1·88)	0·98 (0·41–2·36)*	2·08 (1·57–2·76)	1·56 (1·21–2·02)	1·02 (0·92–1·14)*	1·39 (1·32–1·46)	50·7	80% (66–89)
Stroke	1·38 (1·23–1·55)	1·34 (1·18–1·53)	1·76 (1·37–2·25)	1·56 (1·03–2·37)	1·42 (1·21–1·66)	1·88 (1·40–2·53)	1·19 (0·89–1·59)	1·05 (0·78–1·39)*	1·19 (0·88–1·61)*	1·57 (1·10–2·24)	1·46 (0·96–2·21)*	1·39 (1·31–1·48)	14·6	32% (0–66)
Arthritis or rheumatism	1·41 (1·30–1·53)	1·32 (1·21–1·44)	1·35 (1·17–1·55)	1·32 (0·98–1·75)*	1·29 (1·15–1·45)	1·51 (1·22–1·87)	1·45 (1·23–1·71)	1·06 (0·85–1·33)*	1·24 (0·73–2·11)*	1·37 (1·19–1·57)	1·28 (1·20–1·37)	1·33 (1·28–1·38)	9·7	0% (0–60)
Fainting or blackouts	1·21 (0·91–1·61)*	1·23 (1·03–1·48)	1·17 (0·84–1·66)*	1·02 (0·57–1·79)*	1·04 (0·85–1·27)*	1·44 (0·73–2·82)*	0·97 (0·69–1·37)*	0·96 (0·69–1·33)*	1·31 (0·93–1·85)*	1·14 (0·82–1·58)*	1·37 (1·26–1·49)	1·25 (1·17–1·34)	13·2	24% (0–62)
Difficulty breathing or asthma	1·28 (1·13–1·45)	1·13 (1·01–1·28)	1·26 (1·01–1·58)	1·35 (0·92–1·98)*	1·13 (0·95–1·33)*	1·11 (0·84–1·45)*	1·17 (0·89–1·54)*	1·14 (0·84–1·56)*	1·26 (0·79–2·03)*	1·18 (0·84–1·48)*	1·21 (1·08–1·33)	1·19 (1·13–1·26)	4·4	0% (0–60)
Skin disorders	1·39 (1·12–1·74)	1·73 (1·39–2·13)	1·17 (0·98–1·41)	1·86 (1·32–2·63)	1·04 (0·84–1·28)*	0·99 (0·61–1·63)*	0·86 (0·64–1·16)*	0·97 (0·65–1·45)*	0·99 (0·59–1·68)*	1·35 (0·53–3·47)*	1·02 (0·87–1·19)*	1·18 (1·10–1·28)	32·2*	69% (42–83)*
Stomach or intestine problems	1·15 (1·03–1·29)	1·26 (1·15–1·38)	0·96 (0·84–1·11)*	1·37 (0·91–2·06)*	1·07 (0·96–1·21)*	0·98 (0·79–1·22)*	1·23 (1·03–1·46)	1·05 (0·76–1·44)*	1·03 (0·71–1·51)*	1·06 (0·75–1·48)*	1·17 (1·04–1·33)	1·14 (1·09–1·19)	16·1*	38% (0–69)*
Diabetes	1·07 (0·97–1·16)*	1·05 (0·95–1·16)*	1·22 (1·01–1·46)	1·47 (1·05–2·06)	1·18 (1·05–1·33)	1·11 (0·93–1·32)*	1·23 (1·02–1·49)	1·13 (0·89–1·43)*	0·85 (0·44–1·62)*	1·16 (0·96–1·42)*	1·08 (0·95–1·22)*	1·12 (1·06–1·16)	9·1	0% (0–60)
Eyesight problems	1·22 (1·12–1·32)	1·13 (1·04–1·23)	0·91 (0·79–1·03)*	1·15 (0·96–1·36)*	1·01 (0·89–1·13)*	1·04 (0·86–1·24)*	0·99 (0·85–1·16)*	1·02 (0·81–1·28)*	1·01 (0·79–1·28)*	1·72 (1·36–2·15)	1·11 (1·03–1·18)	1·11 (1·06–1·14)	34·7	71% (47–84)
Hearing difficulties	1·09 (0·98–1·22)*	1·18 (1·06–1·32)	1·17 (1·03–1·34)	1·07 (0·85–1·35)*	1·15 (1·01–1·33)	1·24 (1·04–1·49)	1·02 (0·85–1·22)*	0·92 (0·74–1·14)*	0·99 (0·79–1·25)*	1·22 (0·81–1·82)*	1·04 (0·95–1·15)*	1·11 (1·06–1·15)	10·6	6% (0–63)
Persistent cough	1·37 (1·12–1·68)	1·01 (0·89–1·13)*	1·14 (0·89–1·45)*	1·02 (0·69–1·51)*	1·12 (0·94–1·32)*	1·09 (0·81–1·51)*	0·88 (0·66–1·18)*	0·89 (0·58–1·38)*	1·38 (0·78–2·45)*	1·41 (0·98–2·02)*	1·13 (1·00–1·28)	1·11 (1·04–1·17)	12·9	23% (0–61)
Heart problems	1·07 (0·95–1·21)*	1·12 (0·96–1·29)*	1·01 (0·83–1·24)*	1·19 (0·79–1·81)*	1·04 (0·88–1·23)*	1·03 (0·61–1·73)*	0·93 (0·57–1·51)*	1·42 (1·11–1·83)	1·07 (0·73–1·58)*	1·35 (0·77–2·35)*	1·17 (0·84–1·63)*	1·09 (1·02–1·17)	6·6	0% (0–60)
Myocardial infarction or angina	1·06 (0·95–1·19)*	1·03 (0·84–1·26)*	1·19 (0·97–1·45)	0·86 (0·58–1·27)*	1·34 (1·14–1·58)	0·82 (0·53–1·25)*	0·37 (0·22–0·64)	0·82 (0·60–1·12)*	0·99 (0·54–1·82)*	1·02 (0·73–1·42)*	0·91 (0·73–1·12)*	1·05 (0·98–1·12)*	30·7*	67% (39–83)*
COPD	1·03 (0·86–1·24)*	1·04 (0·91–1·18)*	0·83 (0·65–1·06)*	0·58 (0·39–0·87)	1·15 (0·97–1·36)*	1·09 (0·81–1·47)*	1·11 (0·88–1·38)*	1·14 (0·79–1·66)*	1·31 (0·87–1·94)*	1·12 (0·78–1·57)*	0·96 (0·85–1·09)*	1·02 (0·96–1·08)*	16·2*	38% (0–70)*
Hypertension	0·99 (0·91–1·08)*	0·98 (0·89–1·10)*	1·09 (0·97–1·24)*	0·94 (0·78–1·12)*	1·05 (0·92–1·21)*	1·16 (0·98–1·37)*	1·13 (0·96–1·34)*	1·00 (0·82–1·22)*	0·91 (0·79–1·03)*	1·09 (0·96–1·25)*	0·98 (0·91–1·05)*	1·02 (0·97–1·05)*	12·4*	20% (0–59)*

Data are relative risk (RR; 95% CI), unless otherwise stated. DR=Dominican Republic. COPD=chronic obstructive pulmonary disease. *Associations were not significant. †Adjusted for age, sex, educational attainment, and marital status.

Table 3: Relative risks for associations between disability and self-reported impairments and chronic-disease diagnoses†

WHODAS 2.0 disability scores, especially in a cross-cultural context. Score distributions were overdispersed and zero-inflated in all sites, and ZINB models fitted better than did either Poisson or negative binomial. The large between-site variation in zero inflation is an important finding, with the positive association with zero inflation in China and inverse association in India being most parsimoniously interpreted as a culturally determined predisposition to so-called nay-saying in China and yea-saying in the Indian setting. Having accounted for zero inflation, the count (negative binomial) part of the ZINB model provides the best, most culturally fair perspective on the contribution of chronic diseases to overall disability (table 3). Unfortunately, since this method models the ratio of counts, we were unable to use these values to generate estimates of population effect (either PAPFs or components of variance explained). That our PAPFs had to be generated from a Poisson model (table 4) is therefore a slight limitation.

Our findings are consistent with a report from the Canadian Study of Health and Aging[30] of a substantial excess disability attributable to dementia, after accounting, in multivariate models for comorbidity with physical, mental, and substance-use disorders. In population-based cohort studies of predictors of dependency[31] and institutionalisation[32] in elderly people

in the USA, multivariable analyses show that dementia and cognitive impairment are by far the most strongly and independently associated chronic health disorders. Psychiatric disorders and stroke also made an important independent contribution to dependency.[31] Coronary heart disease, cancer, hypertension, lung disease, diabetes, and hip fracture did not predict dependency, and cardiovascular disease, arthritis, and lung disease were not associated with institutionalisation. Few such studies have been done in countries with low and middle incomes. However, in a cross-sectional study[33] of elderly Chinese people living in Hong Kong, dementia (odds ratio 157·1), stroke (19·3), Parkinson's disease (14·2), and old fractures (2·5) were the chronic disorders most strongly associated with severe limitation. Finally, previous analyses of the same 10/66 Dementia Research Group dataset have shown that dementia is the largest independent chronic disease contributor to dependency, with a PAPF of 65% in Cuba[34] and 44% in Dominican Republic.[35]

Some limitations need to be acknowledged. First, we did not include all chronic-disease domains in our analyses. Presence of cancer or endocrine, genitourinary, and oral disorders was not ascertained. However, according to the Global Burden of Disease report,[2] these excluded disorders make a small contribution to disability, and those that were covered in our study

	Cuba	Dominican Republic	Urban Peru	Rural Peru	Venezuela	Urban Mexico	Rural Mexico	Urban China	Rural China	Urban India	Rural India	PAPF (IQR)
Dementia	43·6%	25·1%	43·2%	22·5%	19·2%	22·4%	21·6%	35·1%	38·9%	19·9%	26·1%	25·1% (19·2–43·6)
Hypertension	*	14·4%†	2·1%†	*	18·3%†	11·8%†	13·8%†	*	16·8%†	15·9%†	*	14·4% (2·1–18·3)
Stroke	11·4%	7·9%	21·4%	13·8%	12·3%	15·4%	7·5%†	21·1%†	1·8%†	6·2%	5·0%†	11·4% (1·8–21·4)
Paralysis or weakness of limb(s)	10·5%	21·3%	7·1%	5·7%†	11·6%	7·5%†	10·4%	30·5%	33·8%	7·9%	11·3%	10·5% (5·7–33·8)
Arthritis or rheumatism	9·9%	14·1%	8·9%	3·2%†	21·1%	9·4%	21·6%	3·3%†	5·6%†	14·4%	34·8%	9·9% (3·2–34·8)
Depression	8·3%	23·0%	7·8%	15·4%	10·8%	6·2%	12·4%	0·5%†	1·7%	8·3%	1·2%†	8·3% (0·5–23·0)
Eyesight problems	17·6%	5·1%	*	*	6·8%†	5·4%†	*	1·7%†	10·8%†	12·1%	17·2%	6·8% (1·7–17·6)
Stomach or intestine problems	3·3%	14·1%	*	10·5%†	4·8%†	6·5%†	23·1%	*	0·3%†	2·5%†	7·9%	6·5% (0·3–23·1)
Diabetes	2·5%†	*	3·3%	8·3%	5·1%	4·1%†	10·9%	5·0%†	0·3%†	3·2%†	*	4·1% (0·3–10·9)
Difficulty breathing or asthma	5·3%	8·9%	*	2·2%†	*	4·3%†	2·1%†	3·7%†	3·2%†	*	8·5%	3·7% (2·1–8·9)
Hearing difficulties	2·2%†	8·9%	1·4%	*	6·1%	9·3%	1·1%†	*	3·0%†	0·8%†	*	2·2% (0·8–9·3)
COPD	<0·1%†	2·5%†	*	*	5·1%†	1·7%†	7·2%†	7·4%†	3·3%†	*	*	3·3% (<0·1–7·4)
Persistent cough	1·4%	*	1·3%†	*	5·4%†	2·2%†	*	*	2·3%†	5·0%†	5·3%	2·3% (1·3–5·4)
Fainting or blackouts	0·8%†	1·2%	2·1%†	*	*	0·5%†	*	1·2%†	2·2%†	*	17·1%	1·2% (0·5–17·1)
Heart problems	*	1·6%†	4·4%†	*	1·8%†	*	0·3%†	15·9%	0·9%†	3·2%†	0·5%†	1·6% (0·5–15·9)
Skin disorders	1·3%	4·4%	4·5%†	3·1%	*	2·1%†	*	*	*	<0·1%†	0·2%†	2·1% (<0·1–4·5)
Myocardial infarction or angina	3·1%†	*	*	0·8%†	4·7%	*	*	*	*	*	0·8%†	0·8% (0·8–4·7)
Total	68·3%	74·5%	62·7%	40·1%	68·3%	64·3%	68·3%	65·1%	69·2%	61·8%	67·6%	67·6% (40·1–74·5)

PAPF=population-attributable prevalence fraction. COPD=chronic obstructive pulmonary disease. WHODAS=WHO disability assessment schedule. *Inverse associations, which were assigned a PAPF value of zero for the purpose of calculation of median population-attributable prevalence fractions. †Calculated from associations that were not significant.

Table 4: Population-attributable prevalence fractions for 90th centile of WHODAS 2.0 scores and health disorders

	YLD (×10⁶) (contribution to total chronic-disease YLDs [%])	Rank order (by YLD)	PAPF*	Rank order (by PAPF)
Dementia	8·3 (10·2%)	3	25·1%	1
Cerebrovascular diseases	3·5 (4·3%)	8	11·4%	2
Musculoskeletal diseases	7·2 (8·9%)	4	9·9%†	3
Neuropsychiatric diseases (other than dementia)	5·9 (7·3%)	6	8·3%	4
Eye diseases	27·5 (33·9%)	1	6·8%	5
Digestive diseases	1·6 (1·9%)	11	6·5%	6
Diabetes mellitus	2·1 (2·6%)	10	4·1%	7
Respiratory conditions	4·3 (5·3%)	7	3·3%‡	8
Hearing loss	9·2 (11·3%)	2	2·2%	9
Skin conditions	0·5 (0·6%)	15	2·1%	10
Heart disease	6·1 (7·6%)	5	0·8%§	11
Oral conditions	2·6 (3·3%)	9	Not assessed	..
Malignant neoplasm	0·9 (1·1%)	12	Not assessed	..
Endocrine disorders	0·8 (1·0%)	13	Not assessed	..
Genitourinary diseases	0·6 (0·7%)	14	Not assessed	..
Total chronic disease burden	81·1 (100%)	..	..	..

YLD=years lived with disability. PAPF=population-attributable prevalence fraction. *From directly measured association with WHO disability assessment schedule 2.0. †Self-reported arthritis or rheumatism. ‡Self-reported symptoms of chronic obstructive pulmonary disease. §Self-reported angina or myocardial infarction. ¶For people aged 60 years and older in countries with low and middle incomes (2004).

Table 5: Contributions of chronic diseases and disorders to disability according to Global Burden of Disease estimates of years lived with disability¶ and median population-attributable prevalence fractions from 10/66 population-based studies

generally accounted for a substantial proportion of disability. Second, and more importantly, not all disorders that were included were ascertained with equivalent rigour. Amartya Sen emphasised the problem of self-report, pointing out that "people in states that provide more education and better health facilities are in a better position to diagnose and perceive their own morbidities than are the people in less advantaged states, where there is less awareness of treatable conditions (to be distinguished from 'natural' states of being)".[36] Our data did not provide very strong evidence for this problem, other than, perhaps, with respect to the low prevalence of self-reported stroke in rural China and India, myocardial infarction or angina in rural Mexico, China, and India, and diabetes in rural India and rural China.

Prevalences of all self-reported impairments were strikingly low in rural compared with urban China, and eyesight problems were infrequently reported in urban India. We cannot exclude the possibility that had we diagnosed some of these disorders by more rigorous clinical assessment, we might have identified more morbidity. By extension, we might have underestimated their contribution to disability in the population with respect to that of dementia and depression, which were diagnosed through detailed clinical interviews. However, despite the fairly low prevalence of eyesight problems in rural China and in India, high PAPFs were recorded, presumably because of poor access to ophthalmic

services, and because we selectively detected the most disabling cases.

Third, our data are cross-sectional. Therefore we cannot attribute causality from the recorded associations between health disorders and disability. Some associations might have been inflated by reverse causality, thus depression can be both a consequence and a cause of disability.[37] Information bias could have occurred, since participants with disabilities might have been selectively more or less likely to have recalled impairments or to have been aware of diagnoses than were those without disabilities. Although population-attributable fractions are conventionally calculated from RRs for incident health outcomes, associations with prevalent disability might be more pertinent to our aims. Our PAPFs incorporate the effect of underlying health disorders on the incidence and duration of disability, and are hence analogous with the YLD approach that was used for the Global Burden of Disease report.[2]

The need to internationalise the disability research agenda is the subject of an important debate. Limitations arise from differences in disability definitions, study methods, and qualities of research across cultural contexts. The major strength of our study is the standard design and assessment procedures, in large representative samples, with high response rates, across three continents. From the outset, the 10/66 Dementia Research Group has been committed to careful cross-cultural validation,[21] and we have now attempted to extend this approach to assessment of disability,[11] in accordance with the evidence already assembled by WHO for the cross-cultural applicability of the International Classification of Functioning, Disability and Health[1] and the WHODAS 2.0 assessment. Although the approach we have used to estimate the contribution of chronic diseases to disability could not replace that used for the Global Burden of Disease report,[2] comparison of the results of these two exercises is illuminating. Such comparison does, at the least, raise important questions about the reasons for the large discrepancies, which would merit further exploration. One possibility is that societal preferences (the Global Burden of Disease disability weights) might not accurately show individual experiences of living with chronic disease (as assessed by the WHODAS 2.0).

Our findings should help to inform debates about priorities for health-service delivery and planning in countries with low and middle incomes. Our findings concur with those of the Global Burden of Disease report,[2] to the extent that the leading causes of disability are very different from the causes of premature death, namely cancer and ischaemic heart disease. The chronic-disease agenda is dominated by prevention of avoidable deaths, and is hence skewed towards primary prevention of these disorders.[38] Of course, prevention of chronic diseases also prevents disability. However,

under the most optimistic of scenarios, the numbers of elderly people living with disabling chronic diseases will continue to rise, especially in countries with low and middle incomes. Our data suggest the need, in particular, for higher priority to be accorded to chronic diseases affecting the brain and mind. Aside from disability, these disorders are very likely to lead to dependency, and to present stressful, complex, long-term challenges to carers. The associated societal costs are enormous—those for dementia alone were estimated as US$315 billion per year worldwide.[39] These individuals, and their families, are very poorly served by health services that remain focused on treatment of acute disorders, and do not provide outreach or continuing care; social protection for elderly people in many countries with low and middle incomes is also grossly inadequate.[40]

A comprehensive response to these challenges will need policies to: prevent disability through control of chronic diseases; reduce disability through active community-based rehabilitation; mitigate effects of disability on participation; and manage disability through universal access to support for family carers and other long-term care options. Such measures are already strongly advocated through international agreements, including the Madrid International Plan for Action on Ageing, and the UN Convention on the Rights of Persons with Disabilities enshrines participation, income, and access to health care as basic rights for all people with disabilities.

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