

BMJ Open Gender inequality and the double burden of disease in low-income and middle-income countries: an ecological study

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ABSTRACT

Introduction Many low-income and middle-income countries (LMIC) suffer from a double burden of infectious diseases (ID) and non-communicable diseases (NCD). Previous research suggests that a high rate of gender inequality is associated with a higher ID and NCD burden in LMIC, but it is unknown whether gender inequality is also associated with a double burden of disease. In this ecological study, we explored the association between gender inequality and the double burden of disease in LMIC.

Methods For 108 LMIC, we retrieved the Gender Inequality Index (GII, scale 0–1) and calculated the double burden of disease, based on disability-adjusted life-years for a selection of relevant ID and NCD, using WHO data. We performed logistic regression analysis to study the association between gender inequality and the double burden of disease for the total population, and stratified for men and women. We adjusted for income, political stability, type of labour, urbanisation, government health expenditure, health infrastructure and unemployment. Additionally, we conducted linear regression models for the ID and NCD separately.

Results The GII ranged from 0.13 to 0.83. A total of 37 LMIC had a double burden of disease. Overall, the adjusted OR for double burden of disease was 1.05 per 0.01 increase of GII (95% CI 0.99 to 1.10, $p=0.10$). For women, there was a borderline significant positive association between gender inequality and double burden of disease (OR 1.05, 95% CI 1.00 to 1.11, $p=0.06$), while there was no association in men (OR 0.99, 95% CI 0.95 to 1.04, $p=0.75$).

Conclusion We found patterns directing towards a positive association between gender inequality and double burden of disease, overall and in women. This finding suggests the need for more attention for structural factors underlying gender inequality to potentially reduce the double burden of disease.

INTRODUCTION

Globally, morbidity and mortality rates attributed to infectious diseases (ID) have dropped considerably since the last decades of the 20th century.¹ However, most low-income and middle-income countries

Strengths and limitations of this study

- The use of country-level data permits an estimation of the association between structural gender inequality and double burden of disease in low-income and middle-income countries.
- We developed a classification of double burden of disease, based on quintiles of disease burden (disability-adjusted life-years) of selected infectious diseases (ID) and non-communicable diseases (NCD) that may be used in further research to investigate the double burden of disease.
- The measure of double burden of disease is limited to available data on ID and NCD and does not include emerging or region-specific ID.
- The measure of gender inequality, the Gender Inequality Index, may not cover all aspects of gender inequality relevant to the burden of NCD or ID.
- Due to the ecological design of the study, the findings provide insight on structural inequality but cannot be interpreted at an individual level.

(LMICs) still struggle with a high ID burden, due to the lack of financial resources of the often fragile healthcare systems.^{2–3} Meanwhile, the adoption of Western nutritional and behavioural habits (eg, increased fast food consumption, alcohol intake and tobacco use) has caused a rapid increase in the burden of non-communicable diseases (NCD), such as diabetes, cancer and cardiovascular diseases (CVD).^{4–7} In 2016, 31.5 million deaths in LMIC were caused by NCD, making up for over 75% of the global NCD mortality.⁸ The combined high burden of ID and NCD is called the double burden of disease. This double burden poses a major threat for LMIC, where the limited financial resources are primarily spent on tackling the problem of ID, often neglecting the problem of NCD.^{4–9} Limited research has been done to identify factors that contribute to the double burden of disease.

We propose that gender inequality may have a role in the emergence of the double burden of disease. Research shows a higher rate of gender inequality in LMIC compared with high-income countries.¹⁰ A high rate of gender inequality indicates large differences in opportunities and rights between men and women within societies.^{10–12} In general, this means that women and men are differently affected by social stigma and gender roles. For women, these differences often lead to less employment and educational opportunities, and financial dependency on men.^{13–17} For men, gender inequality is related to a higher tendency to risky masculine behaviour, including having multiple sex partners, smoking and alcohol abuse.^{12 18 19} These factors may affect men's and women's treatment seeking behaviour, and exposure to pathogens and NCD risk factors, resulting in higher morbidity and mortality rates of both ID and NCD.^{4 12} Indeed, a high rate of gender inequality has been associated with a higher disease burden of tuberculosis, HIV and stroke.^{13 20–23}

Since many healthcare organisations in LMIC aim to tackle the double burden of disease across these multiple areas of health, there is an urgent need for more insight into the potential contribution of societal factors.²⁴ As gender inequality is a known risk factor for both ID and NCD in LMIC, studying the potential association between gender inequality and the double burden of disease could provide useful insights for the development of healthcare policies to tackle the double burden of disease in these countries. However, despite the potential relevance of gender inequality in relation to disease burden in LMIC, research on the association between gender inequality and the double burden of disease remains scarce.²⁴ In this ecological study, we assessed the association between gender inequality and the double burden of disease in LMIC. Specifically, is a higher rate of gender inequality associated with a higher occurrence of double burden of disease in LMIC, and does this association differ between men and women?

METHODS

Country-level data for the classification of gender inequality, double burden of disease and relevant covariates for the entire population and for men and women separately were retrieved from openly available datasets (online supplemental appendix 1). Data on disease burden were available for 180 countries and data on gender inequality were available for 159 countries. For this study, we included all countries classified as low income, lower-middle income and upper-middle income, by the World Bank, with available data on gender inequality and disease burden.²⁵ This resulted in a selection of 108 countries (online supplemental appendix 2).

Gender inequality

The Gender Inequality Index (GII), developed in 2008 by the United Nations Development Programme, was used as a measure for gender inequality.²⁶ This index is a

continuous measure for the degree of gender inequality per country on a scale between 0 and 1. The GII is based on several aspects of gender inequality: (1) reproductive health, measured by the maternal mortality ratio and adolescent birth rates; (2) empowerment, measured by the proportion of parliamentary seats occupied by women and the proportion of adult women and men with at least some secondary education and (3) economic status, measured by labour force participation rate of men and women.²⁶ We used data on GII from 2016.

Double burden of disease

To compute disease burden, we used WHO data on total disability-adjusted life-years (DALYs) per disease (continuous data), which we standardised to DALYs per 1000 persons.²⁷ DALYs are considered a reliable method to describe the burden of disease at country level.²⁸ ID burden was based on DALYs for HIV/AIDS, diarrhoeal diseases and tuberculosis. NCD burden was based on DALYs for ischaemic heart disease, stroke, diabetes and cancer. These diseases were selected because they are among the top 10 causes of death in LMIC.²⁹ Although malaria, respiratory diseases and chronic obstructive pulmonary disease (COPD) also account for a major part of the total disease burden, we did not include these diseases in our definition of double burden of disease, due to missing data (malaria; partly reflecting data collection in endemic vs non-endemic areas) and a high likelihood of overlap between symptoms of diseases (COPD and respiratory diseases). For the measurement of double burden of disease, DALYs per disease per country for the entire population, and separately for men and women, were categorised into quintile groups. Countries with DALYs for at least one ID and one NCD in the two highest quintile groups were considered as facing a double burden. Countries that did not meet these criteria were considered as not having a double burden. This resulted in a dichotomous variable (yes/no) which was added to the analysis as a dummy variable. Data on disease burden were from 2016.

Covariates

Various covariates were selected as potential confounders based on evidence in previous literature.^{30–32} All covariates were added to the dataset as continuous variables. We used World Bank data on income, political stability, type of labour and urbanisation. Income was defined as gross national income per capita. Political stability was measured with survey scores on people's perception of the likelihood of political instability. Type of labour was measured as a percentage of people working in the service sector. Urbanisation was measured as a percentage of people living in urban areas.³³ In addition, we derived data for government health expenditure and health infrastructure from the WHO Global Health Observatory. Health expenditure was defined as a percentage of the total expenditure of the government, and health infrastructure measured by the density of hospitals per 100

000 persons.³⁴ Lastly, we obtained data on unemployment from the Organisation for Economic Co-operation and Development database. Unemployment was measured by the percentage of persons currently unemployed.³⁵ For all covariates, we used the most recent available data per country. All data were from 2016, with the exception of government health expenditure (2014), and health infrastructure (depending on country: 2010, 2013 or 2014).

Statistical analysis

GII values were expressed as means (SD), ranging from 0 to 1. All other country characteristics were expressed as medians (IQR) by tertiles of GII; the lowest tertile representing the countries with low gender inequality, and the highest tertile representing the countries with high gender inequality. The prevalence of double burden of disease and the underlying prevalence of the separate ID and NCD were calculated for the total population of all countries, all men and all women, by GII group. Differences in the characteristics and prevalence of double burden of disease across groups were explored by comparing the descriptive figures across subgroups. Binary logistic regression analyses were performed to study the association between a 0.01 higher rate of gender inequality and the double burden of disease in the total population, men and women. The first model was a crude analysis, without adjustment for any potential confounders. In the second model, we adjusted for income, unemployment, urbanisation, political stability, government health expenditure, type of labour and health infrastructure, to correct for potential confounding.

We performed additional multivariable linear regression analyses to explore the association between gender inequality and the DALYs of each separate disease in the total population, men and women. This was done in order to gain a better understanding of which specific diseases are associated with gender inequality, and possible differences in underlying disease patterns between men and women. A $p < 0.05$ was considered as statistically significant. All analyses were performed using SPSS Statistics V.25.³⁶

Patient and public involvement

Neither patients nor individuals of the public were involved in our research at any stage.

RESULTS

Overall, the GII ranged from 0.13 to 0.83, with a mean GII of 0.28 (SD 0.08) in the low gender inequality group, 0.45 (SD 0.04) in the medium gender inequality group and 0.60 (SD 0.07) in the high gender inequality group. Income, urbanisation rates, government health expenditure, political stability rates, percentage of people working in the service sector, health infrastructure quality and unemployment rates were all lowest in the high gender inequality group (table 1). ID burden was highest in the

high gender inequality group, whereas the NCD burden was lowest in this group.

A total of 37 countries had a double burden of disease (table 1, figure 1). The prevalence of double burden of disease in the total population was higher in the middle and high gender inequality group (40.5% and 43.2% respectively), compared with the low gender inequality group (16.2%). This was also the case for men and women separately, although differences between the low and higher gender inequality groups were smaller in men than in women. Among women, there was a relatively higher occurrence of double burden in the medium and high gender inequality group, but a relatively lower occurrence in the low gender inequality group, compared with men.

The underlying patterns of differences in ID and NCD burden across gender inequality groups were similar for men and women (figure 2). However, absolute estimated burdens within categories varied. For instance, in the low gender inequality group, the burden for cancer was lower in women than men, whereas in the medium and high gender inequality groups, the burden was similar for men and women.

Overall, gender inequality was not significantly associated with the double burden of disease (table 2). However, the estimate points in the direction of an association between higher gender inequality and higher double burden of disease; the adjusted OR of double burden of disease was 1.05 (95% CI 0.99 to 1.10, $p = 0.10$) per 0.01 increase in GII. The association differed for men and women. In men, gender inequality was not associated, whereas in women, gender inequality was borderline significantly associated with the double burden of disease; the odds of double burden increased with 1.05 (95% CI 1.00 to 1.11, $p = 0.06$) per 0.01 increase of GII.

A higher rate of gender inequality was significantly associated with a higher burden of ID, in the total population, and in men and women (table 3). For instance, one unit increase in GII was associated with an adjusted 0.97 higher HIV burden (95% CI 0.39 to 1.55). In contrast, higher gender inequality was significantly associated with a lower burden of NCDs, in the total populations, as well as in men and women. For instance, one unit increase in GII was associated with a 0.31 lower stroke burden in women (95% CI -0.48 to -0.14).

DISCUSSION

While gender inequality is not significantly associated with occurrence of double burden of disease at a country level, we observed a pattern directing towards a positive association between gender inequality and the double burden of disease, overall and in women. Nevertheless, patterns of underlying diseases are similar in men and women.

Our study has several limitations. First, we designed a classification of double burden based on quintiles of disease burden (DALYs) of selected ID and NCD since,

Table 1 Country characteristics per tertile group of GII

	Low gender inequality (n=36)	Medium gender inequality (n=36)	High gender inequality (n=36)
	Median (IQR)	Median (IQR)	Median (IQR)
Income (GNI per capita)	4980 (3790–8800)	3580 (2040–5470)	1120 (600–1680)
Unemployment (%)	7.0 (4.4–14.9)	6.4 (2.7–11.3)	5.5 (2.4–9.7)
Urbanisation (%)	57.4 (46.0–74.2)	57.0 (36.8–70.4)	35.8 (26.4–51.5)
Political stability (survey score, range: –3–3)	0.0 (–0.7–0.3)	–0.3 (–0.9–0.1)	–0.7 (–1.3–0.2)
Labour type (%)	53.4 (46.6–63.1)	54.4 (43.0–62.1)	39.0 (29.0–47.5)
Government health expenditure (%)	11.1 (9.4–13.9)	10.5 (7.1–14.1)	9.6 (6.3–12.2)
Health infrastructure (n of hospitals per 100 000 persons)	2.1 (1.2–3.8)	0.7 (0.4–1.9)	0.5 (0.4–1.3)
Tuberculosis burden (DALYs per 1000 persons)	1.2 (0.6–2.8)	2.4 (1.0–10.1)	12.2 (4.4–23.4)
HIV burden (DALYs per 1000 persons)	1.5 (0.3–3.7)	5.0 (2.6–11.8)	23.1 (8.7–45.9)
Diarrhoeal diseases burden (DALYs per 1000 persons)	1.7 (0.8–2.7)	5.3 (2.9–11.6)	30.1 (17.9–41.7)
Cancer burden (DALYs per 1000 persons)	40.2 (24.4–51.5)	23.7 (20.2–27.8)	18.6 (15.2–22.1)
Diabetes burden (DALYs per 1000 persons)	9.4 (6.1–13.7)	10.8 (8.7–13.4)	5.5 (4.7–8.1)
IHD burden (DALYs per 1000 persons)	35.3 (20.7–53.9)	20.4 (13.4–27.8)	14.2 (10.5–21.8)
Stroke burden (DALYs per 1000 persons)	17.3 (11.7–35.4)	10.8 (8.3–16.0)	11.9 (9.3–15.5)
	n (%)	n (%)	n (%)
Double burden of disease			
Total	6 (16.2)	15 (40.5)	16 (43.2)
Men	10 (23.8)	18 (42.9)	14 (33.3)
Women	4 (12.5)	14 (43.8)	14 (43.8)

DALY, disability-adjusted life-year; GII, Gender Inequality Index; GNI, gross national income; HIV, human immunodeficiency viruses; IHD, ischaemic heart disease; ;IQR, interquartile range.

to our knowledge, no validated definition of the double burden is available. Consequently, we cannot compare our estimates against a gold standard, and the choices

made within this classification may have affected our estimates. However, in exploratory analyses, we have evaluated various other methods for defining the double

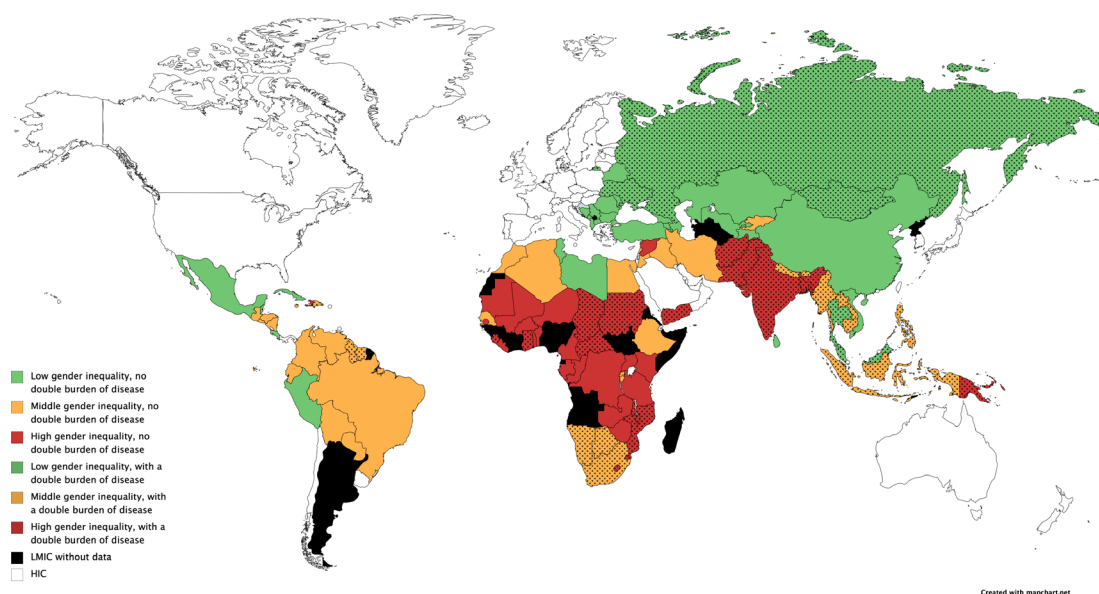


Figure 1 Gender inequality and the occurrence of double burden of disease among the total population, per country. LMIC, low-income and middle-income country; HIC, high-income countries.

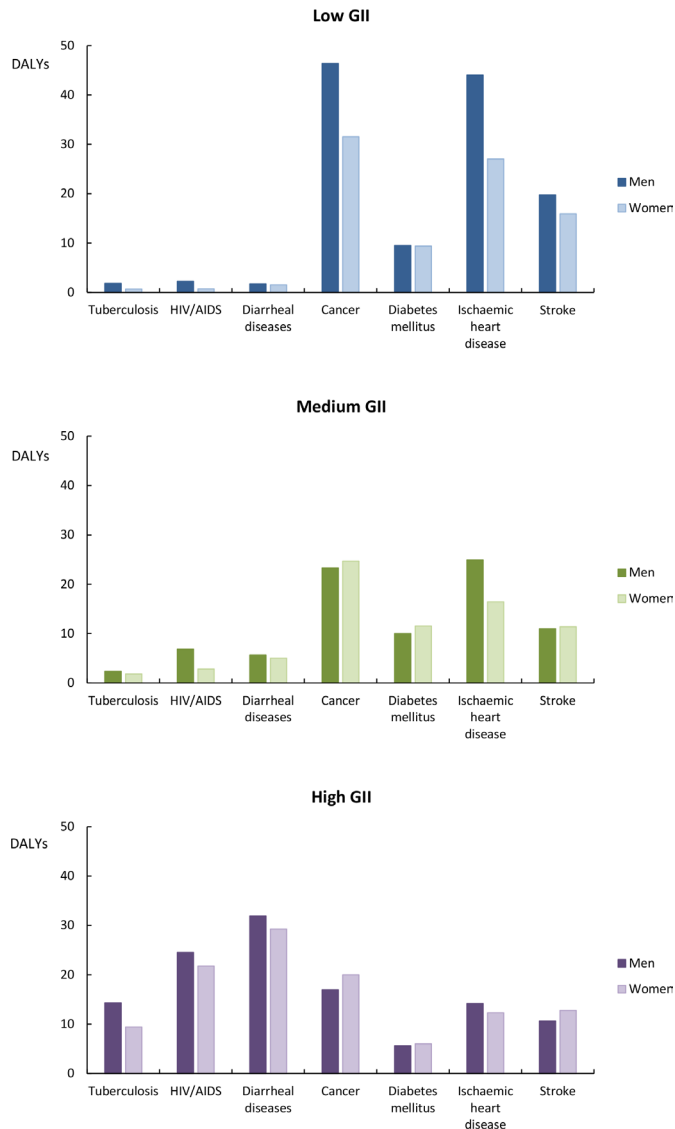


Figure 2 Median disease burden (DALYs) of all included diseases, per tertile group of Gender Inequality Index (GII), stratified by sex. DALYs, disability-adjusted life-years.

burden of disease, including classification into tertile and quartile groups, rendering similar results (data not shown). Second, we selected the most frequently occurring diseases for which data on disease burden and gender inequality were available in all countries. This selection may not sufficiently reflect total disease burden, or adequately capture the variation across countries,

since it ignores diseases that have a regional impact. In addition, it does not capture effects of recent emerging ID such as COVID-19. If such emerging infections impact LMIC differently in the long term, compared with traditional ID, it may result in different patterns of double burden of disease across countries.³⁷ Third, our measure of gender inequality may be imperfect. Gender inequality is a complex concept, consisting of structural aspects such as female representation in the labour force and differences in education, but also social and cultural norms that may affect both female and male health.¹² Several studies argue that some of these aspects of gender inequality are not sufficiently represented in the GII.^{38–41} We expect that this may have resulted in a biased estimation of the true impact of gender inequality on the double burden of disease. Lastly, the cross-sectional and ecological nature of this study introduces some limitations to be considered when interpreting the results. Because this is a cross-sectional study, no statements can be made about causality. It cannot be ruled out that a high occurrence of ID or NCD lead to a higher gender inequality rather than the other way around. Moreover, since we used data at country-level, our findings cannot be interpreted at an individual level (ecological fallacy).^{42 43}

Although we observed no statistically significant associations between gender inequality and double burden of disease, we found patterns suggesting that a higher rate of gender inequality was associated with higher odds of a double burden of disease, overall and particularly in women. No previous studies have specifically addressed the association between gender inequality and the double burden of disease, but some studies investigated the association between gender inequality and several ID and NCD.^{13 20–23} They suggest several pathways in which gender inequality affects disease burden. For example, gender inequality leads to less employment and educational opportunities for women, causing dependency on men in many aspects of their life. This dependency often causes women to refrain from seeking treatment.^{13–17} In addition, men tend to smoke more often than women in countries with a higher GII, putting them at a higher risk for NCD such as stroke.^{18 19} Our observations for the association between gender inequality and ID burden were similar to prior studies. For instance, in line with a global study by Richardson *et al*,²¹ we found that more gender inequality was associated with a higher HIV burden.

Table 2 The association between gender inequality and the double burden of disease in all countries, men and women, per 0.01 difference in GII

	Total		Men		Women	
	OR (95% CI)	P value	OR (95% CI)	P value	OR (95% CI)	P value
Crude	1.04 (1.01 to 1.08)	<0.01	1.02 (0.99 to 1.04)	0.27	1.05 (1.02 to 1.09)	<0.01
Adjusted*	1.05 (0.99 to 1.10)	0.10	0.99 (0.95 to 1.04)	0.75	1.05 (1.00 to 1.11)	0.06

*Adjusted for income, unemployment, urbanisation, political stability, government health expenditure, type of labour and health infrastructure. CI, confidence interval; GII, Gender Inequality Index; OR, odds ratio.

**Table 3** The association between gender inequality and tuberculosis, HIV, diarrhoeal diseases, cancer, diabetes, IHD and stroke in all countries, men and women

	Total		Men		Women	
	Beta (95% CI)	P value	Beta (95% CI)	P value	Beta (95% CI)	P value
Tuberculosis						
Crude	0.28 (0.19 to 0.37)	<0.001	0.32 (0.20 to 0.44)	<0.001	0.24 (0.17 to 0.30)	<0.001
Adjusted*	0.23 (0.06 to 0.32)	<0.01	0.27 (0.10 to 0.43)	<0.01	0.19 (0.10 to 0.27)	<0.001
HIV						
Crude	0.79 (0.29 to 1.30)	<0.01	0.78 (0.26 to 1.29)	<0.01	0.81 (0.31 to 1.31)	<0.01
Adjusted*	0.97 (0.39 to 1.55)	<0.01	0.91 (0.33 to 1.48)	<0.01	1.04 (0.45 to 1.62)	<0.01
Diarrhoeal diseases						
Crude	0.90 (0.71 to 1.08)	<0.001	0.95 (0.75 to 1.15)	<0.001	0.85 (0.68 to 1.02)	<0.001
Adjusted*	0.69 (0.45 to 0.93)	<0.001	0.74 (0.48 to 1.02)	<0.001	0.64 (0.41 to 0.87)	<0.001
Cancer						
Crude	-0.65 (-0.79 to -0.52)	<0.001	-0.88 (-1.05 to -0.70)	<0.001	-0.44 (-0.54 to -0.34)	<0.001
Adjusted*	-0.60 (-0.80 to -0.39)	<0.001	-0.78 (-1.05 to -0.51)	<0.001	-0.43 (-0.59 to -0.27)	<0.001
Diabetes						
Crude	-0.08 (-0.19 to 0.03)	0.14	-0.10 (-0.22 to 0.02)	0.09	-0.06 (-0.17 to 0.05)	0.25
Adjusted*	0.02 (-0.15 to 0.18)	0.86	0.00 (-0.18 to 0.18)	0.99	0.03 (-0.13 to 0.19)	0.73
IHD						
Crude	-0.77 (-1.01 to -0.54)	<0.001	-0.96 (-1.23 to -0.68)	<0.001	-0.60 (-0.80 to -0.40)	<0.001
Adjusted*	-0.73 (-1.03 to -0.43)	<0.001	-0.90 (-1.27 to -0.54)	<0.001	-0.56 (-0.82 to -0.31)	<0.001
Stroke						
Crude	-0.34 (-0.46 to -0.22)	<0.001	-0.39 (-0.51 to -0.26)	<0.001	-0.29 (-0.41 to -0.17)	<0.001
Adjusted*	-0.36 (-0.53 to -0.19)	<0.001	-0.42 (-0.60 to -0.24)	<0.001	-0.31 (-0.48 to -0.14)	<0.01

*Adjusted for income, unemployment, urbanisation, political stability, government health expenditure, type of labour and health infrastructure. CI, confidence interval; HIV, human immunodeficiency viruses; IHD, ischaemic heart disease.

However, our study shows that the burden of individual NCD was lower in countries with more gender inequality. This finding is in contrast to, for instance, the study by Kim *et al*,¹³ which showed that stroke mortality rates were higher for countries with a high gender inequality. Explanations for this discrepancy are unclear, but may be related to differences in inclusion of all countries vs only LMIC in our study. Moreover, the study by O'Neil *et al*¹⁴ states that more gender empowerment (ie, less gender inequality) is associated with an increase in CVD risk factors in women, which could explain why we found a higher NCD burden in countries with a lower GII. Furthermore, in LMIC with more gender inequality, there may be more under-reporting of NCD, causing a lower reported amount of DALYs for these diseases. Healthcare policies in LMIC are mostly focused on reducing the burden caused by ID, while less attention is given to NCD screening, which may cause the reported disease burden to be low in the total population.⁴⁴

Our findings suggest that the estimate for the association (although borderline significant) between gender inequality and double burden is more prominent in women, compared with men, which is in line with previous research.^{22 45} For instance, Heise *et al*¹² showed that a high

gender inequality may be associated with a lack of autonomy and lack of decision-making power over financial resources in women, potentially limiting women in seeking health-care. This might result in under-reporting of NCD among women, and subsequently in an underestimation of the association between gender inequality and NCD burden in our study.⁴⁶ Some studies suggest that gender inequality also affects disease burden in men.^{12 14} It is possible that, while men suffer from higher disease-specific burden in countries with more gender inequality, the mechanisms in which gender inequality influences the simultaneous high burden of ID and NCD in men are different than those in women. Further studies on these potential mechanisms are needed to support this hypothesis.

Other studies suggest that there may be differences in how gender inequality affects subgroups of society, based on, for example, age and whether people live in an urban or rural area.⁴⁷⁻⁴⁹ This was beyond the scope of the current study, but could be explored further in future work using regional population-level data. It should then also be investigated how population-level associations translate to individual-level benefits. Such studies may also elucidate how structural inequalities at country-level relate to individual level perceived norms and expectations regarding gender roles,

such as the division of household tasks, and on feminine and masculine health-related behaviour.^{12 14} In addition, future research may investigate how varying definitions or naturally occurring changes in conditions such as changes in gender inequality over time, local introduction of new healthcare services and the spread of new emerging diseases (eg, COVID-19) among subgroups relate to the occurrence of a double burden of disease. Taken together, these works will provide insight into the direction and potential causality of the association with health.

In this study, we explored the association between gender inequality and the double burden of disease. Our findings suggest that factors underlying gender inequality may be relevant for the occurrence of double burden of disease in LMIC, particularly in women. If elaborated in further research, this highlights the need for more attention for structural factors underlying gender inequality to potentially reduce the double burden of disease. These include factors in the fields of healthcare, research, and policy.

Contributors MCP and IGMvV contributed to the conception of the work; all authors contributed to the design. MvdH and Adv contributed to the analysis; all authors contributed to the interpretation of the results. MvdH drafted the manuscript. RB, Adv, MCP and IGMvV critically revised the manuscript. All authors gave final approval and agree to be accountable for all aspects of work ensuring integrity and accuracy.

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Competing interests None declared.

Patient consent for publication Not required.

Ethics approval As the Dutch Medical Research Involving Human Subjects Act did not apply to this study, explicit ethical approval was not needed.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement Data are available in a public, open access repository. All data are available in openly available datasets from the OECD, WHO, World Bank and UNDP.

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