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Impact of multimorbidity on health service use, catastrophic health expenditure, and productivity loss in Indonesia: a population-based panel data analysis study

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Impact of multimorbidity on health service use, catastrophic health expenditure, and productivity loss in Indonesia: a population-based panel data analysis study

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Abstract

Objectives To examine multimorbidity levels, and their relation to households' socioeconomic characteristics, health service use, catastrophic health expenditures, and productivity loss.

Design This observational study utilised a panel data of the Indonesian Family Life Survey (IFLS) conducted in 2007 (Wave 4) and 2014 (Wave 5).

Setting The original sampling frame was based on 13 out of 27 provinces in 1993, representing 83% of the population in Indonesia.

Participants We included respondents aged 50 years and above in 2007, excluding those who did not participate in both Waves 4 and 5. Total participants in this study are 3,678 respondents.

Primary outcome measures This study examined three main outcomes; health service use (outpatient and inpatient care), financial burden (catastrophic health expenditure), and productivity loss (labour participation, days primary activity missed, days stayed in bed).

Results Multimorbidity increased with sex, higher economic status, and higher education attainment. Multimorbidity was associated with a substantially higher number of outpatient visits (compared with those without NCDs, incidence rate ratio [IRR] 4.30, 95% CI 3.37–5.47 for individuals with three or more NCDs), a higher number of hospital visits (IRR 5.76, 95% CI 3.11–10.66 for individuals with three or

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more NCDs). Multimorbidity was also associated with a greater likelihood of experiencing catastrophic health expenditure (for three or more NCDs, adjusted odds ratio [aOR] 1.68, 95% CI 0.13–2.52) and a lower participation in labour force (for three or more NCDs, aOR 0.18, 95% CI 0.10–0.34) compared to those without NCDs.

Conclusions Multimorbidity is associated with substantial direct and indirect costs to individuals, households, and the wider society. Our study highlights the importance of preparing health systems for addressing the burden of multimorbidity in LMICs.

Keywords Multimorbidity, Indonesia, noncommunicable diseases, health service use, catastrophic health expenditure, productivity loss.

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Strengths and limitations of this study

- To our knowledge, our study provides the first comprehensive analysis using the only large longitudinal survey in Indonesia, which examined the impact of multimorbidity on health service use, catastrophic health expenditure, and productivity loss.
- This study applied multilevel mixed-effects regression models approach to examine factors associated with multimorbidity and its relation to the outcome variables, while taking into account the hierarchical (nested) nature of the dataset.
- Our findings should be interpreted with causation since the assessment of chronic diseases was mostly based on self-reporting, which may cause under-reporting of the prevalence.
- Despite the fifth waves of IFLS dataset was conducted between 2014 and 2015, the longitudinal design of the survey is extremely useful for measuring the impact of chronic diseases, accounting for within-individual variations over-time.

Introduction

Noncommunicable diseases (NCDs) continues to be the main cause of global burden of diseases, with 78% of NCD-related mortality concentrated in low-income and middle-income countries (LMICs).[1] Current COVID-19 global pandemic proves that the presence of NCDs can also increase fatality risk of a communicable disease.[2] In Indonesia, the third most populous country among LMICs (after China and India) with a population of 273 million, has seen rapid demographic and epidemiological transitions over the last few decades. The threat of NCDs is expected to rise with the aging population, or population aged 65 or above, that is projected to account for a quarter of the population by 2070.[3] Concurrently, the prevalence of multimorbidity, defined as the presence of two or more NCDs, is expected to rise rapidly in many LMICs as life expectancy with exposure to risk factors increase.[4] Indonesia has started recognizing NCDs burden for its substantial contribution to the top causes of death and disability-adjusted life years (DALYs).[5] NCDs are now on one of targets on 2020–2024 National Medium-Term Development Plan and warrant one of key considerations on national health account.[6] However, current health programs remain limited to the

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curative services focusing on single chronic disease as oppose to focusing on assessing and mitigating the impact of multimorbidity on individual, health system and wider society.

Current COVID-19 pandemic supplies hard evidence on the importance of strong health system to better respond multimorbidity. Historically, the growing burden of multimorbidity for health systems in LMICs were highlighted in the United Nations High-Level Meetings on NCDs in 2011, 2014, and 2018.[7] LMICs typically have low levels of government expenditure for health and inadequate health insurance coverage. This very often results in high levels of out-of-pocket expenditure (OOPE) and risk of impoverishing health care spending for patients with long-term health conditions.[8,9] The economic burden multimorbidity is further compounded by the fact that multimorbid patients are typically managed by multiple healthcare specialists in LMICs.[10] This leads to inefficiencies with numerous different hospital visits, polypharmacy, and suboptimal disease management.[10,11]

Evidence from high-income countries (HICs) has found that apart from the negative impact on health outcomes, multimorbidity imposes substantial economic costs on individuals and households as patients with multimorbidity incur large medical expenditures and are more likely to be absent from work.[9,12,13] To the best of our knowledge, there is no study in Indonesia that has have examined the economic burden of multimorbidity, as earlier studies have focused on the burden of a single NCD (such as cardiovascular disease and diabetes).[14] As Indonesia constitute a vast and diverse population and has the most diverse set of topologies and economic conditions, our study may contribute to inform health systems reform across the region and beyond.

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We present the first study that uses longitudinal data to examine multimorbidity levels, and their relation to households' socioeconomic characteristics, health service use, catastrophic health expenditures, and productivity loss. Our findings on multimorbidity will support decision makers on the measures towards a more efficient and strengthen health system in Indonesia.

Methods

Sample and data

The study used panel data from two waves of the Indonesian Family Life Survey (IFLS) conducted in 2007 (Wave 4) and 2014 (Wave 5). IFLS is an ongoing longitudinal survey that started in 1993 with four subsequent rounds of data collection (1997/1998, 2000, 2007/2008, and 2014). The original sampling frame was based on 13 out of 27 provinces in 1993, representing 83% of the population. Wave 5 was conducted between September 2014–March 2015, with 76% re-contact rate from the Wave 1 main respondents. The dataset contains individuals' and their household information, including sociodemographic characteristics, healthcare utilisation, health expenditure, and employment participation. The survey objectives and methods are detailed elsewhere.[15,16] In our analysis, we included respondents aged 50 years and above in 2007, excluding those who did not participate in both Waves 4 and 5, and those with missing values for the study variable. Our final sample is 3,678 respondents (sample flowchart is presented in Figure S1). We report this study according to the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines (Table S1)

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Variables

Multimorbidity

Our main variable of interest was multimorbidity. The number of NCDs that was included in Wave 5 was 14, but it was only 10 NCDs in Wave 4. For consistency, our main analysis used 10 NCDs that were available in both waves. The 10 NCDs that were consistently measured were the following: hypertension, diabetes, asthma, heart attack/coronary heart diseases, liver disease, stroke, cancer, arthritis/rheumatism, hypercholesterolemia, and depression/mental illness. The four NCDs that were only included in Wave 4 were: prostate diseases, kidney diseases (excluding malignancy), digestive diseases, and memory-related diseases.

NCD status was either identified through self-reporting or physical examination. In the self-report section, respondents who answered affirmatively to the question, "Has a doctor/paramedic/nurse/midwife ever told you that you had any of these conditions?", were defined as reporting an NCD. For hypertension and hypercholesterolemia, the diagnoses were confirmed through physical examination conducted by trained nurses, i.e. blood pressure and total cholesterol levels. All IFLS respondents aged 15 years and older had their blood pressure recorded three times on alternate arms using Omron self-inflating sphygmomanometers by trained nurses.[15,16] In our analysis, a respondent was categorised as having hypertension if the mean measurement of systolic blood pressure was $\geq$ 140 mm Hg and/or mean diastolic blood pressure was $\geq$ 90 mm Hg or the respondent self-reported having been diagnosed with hypertension.[17] We also included hypercholesterolemia, defined as total blood cholesterol value $\geq$ 240 mg/dl, as morbidity.[18] It is important to note that different measurements of hypercholesterolemia

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were used in Wave 4 and 5. Blood test for total cholesterol was performed in Wave 4 as opposed to self-reporting of hypercholesterolemia in Wave 5.

For our analyses, a total of 10 NCDs were used to quantify the number of NCDs (0, 1, 2, 3 or more) and respondents with two or more NCDs were categorised as having multimorbidity (categorised as 0 or 1). Previous studies have typically considered hypertension, obesity, and hypercholesterolemia as risk factors of NCDs and their inclusion in the multimorbidity clustering remains inconsistent.[4,13] Therefore, in the sensitivity analysis, we included obesity, defined as having BMI ≥25 kg/m^2, in the clustering of multimorbidity (Table S10–12).[19] All statistical analyses were conducted using STATA 13.0.

Outcome variables

This study examined three main outcomes; health service use and financial burden as the direct cost and; productivity loss as the indirect cost of multimorbidity. Respondents were asked about the number of outpatient visits (in the last four weeks) and inpatient visits (in the last 12 months) and out-of-pocket expenditure (OOPE). The data on OOPE was also collected with four weeks recall period for outpatient visits and 12 months recall period for inpatient visits (in the past year). We calculated the total annual OOPE by multiplying OOPE for outpatient visits with 13 (as the reference period of outpatient expenditure in the IFLS is four weeks and a year consists of 52 weeks), and added OOPE for inpatient visits.

Catastrophic health expenditure occurs when OOP spending on health services exceed certain proportions of a household's expenditure. The proportions, or thresholds, used

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in this study were 10% and 25% of total household expenditure (as proposed the Sustainable Development Goal 3 (SDGs) targets), and the WHO's recommendation at 40% of household's capacity to pay. Capacity to pay is defined as the household's capacity to pay for other expenses, including medical costs, after having household subsistence needs met.[20] Household subsistence needs are proxied by the household non-food expenditure variable. Catastrophic health expenditure ($cata_h$) occurrence is expressed as follows:

$$cata_h = 1 \; if \; \frac{HS_h}{THE_h} or \; \frac{HS_h}{CTP_h} > z, \text{ and otherwise is zero.}$$

Where $HS_h$is the total OOPE for health, THE_h is the total household expenditure, CTP_h is capacity to pay, and z is given thresholds. All monetary values were adjusted for inflation and converted to 2014 International Dollars.[21]

Productivity loss was assessed based on three variables: (1) labour participation; (2) the number of days of primary activity missed due to poor health; and (3) number of days confined to bed. Labour participation status was defined as the respondent's employment status at the time of the survey. The number of days of primary daily activity missed and days confined to bed were included in the health conditions section of the survey with four weeks recall period.

Covariates

Sociodemographic factors included were: sex, age groups (50-60, 61-70, above 70 years), marital status (not currently married and currently married), education (no education, primary, junior high school, senior high school, tertiary), ethnicity (Javanese, Sundanese, others), coverage of health insurance (no, yes), type of work (unemployed, casual, self-employed, government/private), and respondents' economic status (per capita expenditure for consumption). The economic status was categorized

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into quintiles: q1 (lowest) to q5 (highest). We also included residency (rural, urban), region of residency (Java-Bali, Sumatra, Nusa Tenggara, Kalimantan, Sulawesi), and period (using wave 2007 as the reference group) as covariates. Detailed definitions and categorisations are available in (Table S2). It should be noted that IFLS did not include the eastern regions, Papua and Papua Barat, which are considered to be underdeveloped.

Statistical analysis

We described the patterns of multimorbidity across different population subgroups and presented the weighted percentages with 95% confidence interval (CI). Taking into account the hierarchical (nested) nature of the dataset (i.e. observations nested within individuals, and individuals nested within households, and districts),[22] a multilevel level model approach was used to examine factors associated with multimorbidity and its relation to the outcome variables. Multilevel negative binomial regression models were performed to examine the association between multimorbidity and the numbers of outpatient visits and days in the hospital. We used negative binomial models instead of Poisson models due to over-dispersion of the count data variable. We applied multilevel logistic regression models to observe binary outcome variables and calculated the intra-class correlation coefficients (ICC). The multilevel analyses were conducted using unweighted data as our aim was on testing the association between multimorbidity and the outcomes and examine the mixed effects, rather than deriving nationally representative estimates.[23] We also conducted a robustness check to investigate the association between multimorbidity and costs using the 2014 cross-sectional dataset, that contains information for four additional NCDs than the 2007 Wave.

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Patient and public involvement

No patients were involved in this study. Members of the public were not directly involved in this study.

Results

Descriptive statistics

Our total sample size was 3,678 respondents. Table 1 presents the respondents' characteristics by multimorbidity status in 2007 and 2014. The median age in 2007 was 58 years (IQR 54–65), 53.9% [95% CI were female, 74.4% were married, 16.5% had at least secondary level or above education, just 25.5% had health insurance coverage, and 77.5% live in Java-Bali region. In 2014, the median age was 65 years (IQR 60–72), and health insurance coverage increased to 42.8%.

<< insert Table 1>>

Overall, the prevalence of multimorbidity increased from 21.0% (95% CI 19.6–22.6) in 2007 to 22.0% (95% CI 20.6–23.6) in 2014. The prevalence of multimorbidity increased with rising socioeconomic status. For example, in 2014, the prevalence was 18.0% (CI 16.9–20.7) in respondents with no education compared to 41.2% (95% CI 31.6–51.6) in those with tertiary education. Similarly, the prevalence increased from 13.5% (95% CI 11.1-16.2) to 36.2% (95% CI 32.2–40.5) between the lowest and highest wealth quintiles. The trend of increasing multimorbidity was observed for all age groups, shown in Fig 1, where the fifth and fourth household expenditure quintiles had a higher prevalence of multimorbidity than lower quintiles.

<< insert Figure 1>>

Table 1 presents the factors associated with multimorbidity. The regression results show that multimorbidity was more likely among those with higher socioeconomic status. Respondents in the highest household expenditure were more likely to report

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multimorbidity, compared with those in the lowest household expenditure quintile (aOR 2.22, 95% CI 1.72–2.86). In comparison with those with lower educational attainment, respondents with higher educational attainment were more likely to experience multimorbidity (aOR 1.54, 95% CI 1.01–2.34 for tertiary level completed). Additionally, the prevalence of multimorbidity was higher in females than males (aOR 1.74, 95% CI 1.46–2.08) and those living in urban areas (aOR 1.41, 95% CI 1.19–1.67). The ICC shows that above 53% (1-[0.34+0.13]) of the variance can be ascribed to between-individual level differences (Table S4).

Multimorbidity and health service use

People with multimorbidity had a higher rate of outpatient and inpatient visits (Table 2). In 2014, the proportion of outpatient visits among respondents with three or more NCDs (55.9% [95% CI 49.0–62.6]) was greater than those without NCDs (15.5% [95% CI 13.3–17.9]). Similarly, for inpatient visits, only 3.3% (95% CI 2.3–4.8) of those without NCD used inpatient service within one year of the survey compared to 20.8% (95% CI 15.7–27.0) among those with three or more NCDs.

<< insert Table 2 >>

Our findings (Table 3) showed the association between the number of NCDs and health service use. The probability of using outpatient care and the number of visits increased with more NCD diagnoses. For instance, respondents with a single NCD were 1.35 times more likely (95% CI 1.15–1.58) to have experienced an outpatient visit in the past four weeks compared to those without an NCD. The odds of an outpatient visit increased to 4.66 times (95% CI 3.55–6.11), while the incident rate increased by 4.25 times (95% CI 3.33–5.42) in those with three or more NCDs. Similarly, the existence of NCD diagnosis increased the probability and number of inpatient visits. The

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incidence of inpatient visits was 3.68 times (95% CI 2.21–6.12) higher in those with three or more NCDs, compared to those without an NCD.

We reported the results of ICC in Table S4. We found that 14% and 11% of the variance in the outpatient visit were attributable to the differences within-individual and households, respectively. Between-individual variation accounted for the largest variation, where it explained 75% (1-[0.14+0.11]) and 65% (1-[0.25+0.12]) of outpatient and inpatient visit, respectively. No influence of district–level variables was shown (ICC=0).

<< insert Table 3 >>

Multimorbidity and financial burden

The mean OOPE for outpatient care incurred by respondents during the last four weeks increased from INT$17 in those without any NCDs to $60 in those with three or more NCDs in 2014 (Table 2). Similarly, for inpatient visits, having three or more NCDs resulted in higher mean OOPE of $762 (SD ± $1,421) compared to $566 (SD ± $1,880) for those without any NCDs. Total annual OOPE also increased from $295 (SD ± $977) among those without any NCDs to $968 (SD ± $4,313) among those with three or more NCDs. Table 2 also presents the proportion of respondents with catastrophic health expenditure using different household budget thresholds. At 10% of total household expenditure threshold, 5.0% (95% CI 3.7–6.6) of households without any member having any NCDs experienced catastrophic health expenditure compared to 12.5% (95% CI 8.7–17.7) of households with a member/s diagnosed with three or more NCDs. The results using 25% of total household expenditure and 40% of non-food consumption thresholds also suggest that households with a member/s diagnosed with

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more than two NCDs had a higher proportion of catastrophic health expenditure compared to households without any member having any NCDs.

Table 4 presents the logistic regression results for the proportion of respondents who experienced catastrophic health expenditure, using both total household expenditure and non-food expenditure thresholds. At 10% of total household expenditure as the threshold, having two NCDs increases the odds of catastrophic health expenditure to 1.58 times (95% CI 1.06–2.35), compared to having none. These odds increased to 1.69 times for those having three NCDs or more (95% CI 1.02–2.81). At 25% and 40% thresholds, we found no significant association between the number of NCD diagnoses and the incidence of catastrophic health expenditure.

<< insert Table 4 >>

Multimorbidity and productivity loss

More NCDs diagnoses was associated with greater productivity loss (Table 2, Table 5). For example, among those aged 50–60 years old, only 49.8% (CI 36.7–62.9) of respondents with three or more NCDs were employed, compared with 84.3% (CI 79.8–88.0) of respondents without NCDs (Table 2). The mean number of days of primary daily activity missed increased substantially from 2.7 days (SD ± 6.0), for those without any NCDs, to 10.1 days (SD ± 12.1) for those with three or more NCDs. The mean number of days confined to bed also increased from 0.80 days (SD ± 3.4), for those without any NCD, to 2.4 days (SD ± 6.3) for those with three or more NCDs.

Table 5 presents that individuals diagnosed with three or more NCDs were 0.23 times less likely (95% CI 0.16–0.33) to be employed compared to those without NCDs. Compared with those without NCD, being diagnosed with multiple NCDs (three or

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more) were expected to have a higher incidence rate of missing days of primary activity (IRR 2.59, 95% CI 1.97–3.41) as well as days spent in bed (IRR 2.64, 95% CI 1.60–4.36). We found that 48% of the variance in the labour participation was due to within-individual variations, while between-individual variation accounted for 23% (1-[0.48+0.28+0.01]) (Table S4).

<< insert Table 5>>

Robustness check

Our robustness analysis using cross-sectional analysis using 2014 cross-sectional dataset that consists of 14 physical NCDs (Table S5-8) showed consistent results with our original findings. Higher household expenditure (aOR 2.03, 95% CI 1.65–2.50 for the highest quintile, compared with the lowest quintile and education status) and higher education (aOR 1.77, 95% CI 13.3–2.36 for tertiary level completed, compared with those with no formal education) were associated with greater burden of multimorbidity. Also, in line with our original findings, multimorbidity was associated with higher health care use, higher incidence of catastrophic health expenditures, and lower productivity. The association between multimorbidity and catastrophic health expenditure was more pronounced in the cross-sectional analysis.

Discussion

Our study provides the first comprehensive analysis of multimorbidity in Indonesia using the only large panel dataset in Indonesia. Our study reveals that almost one in four Indonesian people aged 50 years or above has at least two NCDs, with 6.5% having three or more in 2014. Our findings show a higher prevalence of multimorbidity in richer population groups (as measured by household per capita expenditure in the

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surveys). Multimorbidity was associated with higher use of healthcare services, higher probability of catastrophic health expenditure, and a reduction in productivity.

Analyses of socioeconomic gradients of NCDs in HICs routinely find negative socioeconomic gradients. However, this is not the case for LMICs, which have a more mixed pattern of the distribution of risk factors.[24,25] Other studies find a similar picture with diabetes and cardiovascular diseases in LMICs undergoing epidemiological transition.[25] These conditions predominate in high-income quintiles in early stages of transition. However, our results on socioeconomic patterning of multimorbidity can also be explained by the fact that higher-income and higher-educational groups, who have better access to healthcare services and better health literacy, are more likely to have NCDs diagnosed (or even over-diagnosed) than lower socio-income groups.

Our findings that show having more NCDs is associated with greater use of outpatient and inpatient services is in line with earlier studies from both HICs and LMICs.[4,10,26] The presence of multimorbidity was also associated with a greater financial burden, as measured by catastrophic health expenditures, which is mainly driven by higher healthcare use; these findings are consistent with earlier studies.[4,11,26,27] Based on a previous Indonesian study, four NCDs (hypertension, diabetes, heart problems, and stroke) are the leading causes of mortality, and were estimated to account for 12% of Indonesia's OOPE in 2020.[13] Furthermore, impoverishment effect of multimorbidity has been previously documented and is confirmed in our study.[8,9,12,13]

This study contributes to the growing evidence that multimorbidity has a substantial impact on disability and employment productivity.[8,10,13] Interventions that can help

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effectively manage multimorbidity have the potential for generating substantial returns on improved health, work productivity and social benefits. Therefore, strategies aimed at addressing multimorbidity can be considered as an 'investment' rather than a cost, with the costs of the interventions largely 'offset' by long-term cost savings achieved from improved health and productivity.[28]

This study provides the first evidence to inform policies and the development of targeted strategies for multimorbidity in Indonesia, where preventive and promotive services against NCDs are inadequate and a large portion of government health expenditure is still geared towards curative care.[5] Renewing focus on health promotion and NCD prevention requires a strong primary health care (PHC) system.[10] PHC is the entry point of a sustainable health system for the early detection of risk factors and initiation of treatment-seeking pathway for patients with NCDs, and thus, plays a crucial role for NCD prevention and provision of long-term integrated care. Such policies would be in line with the current program of the Ministry of Health in Indonesia to reorient public PHC to provide more promotive and preventive health services, such as through the implementation of Chronic Diseases Management Program (Prolanis) in PHC.[29,30] However, the participation to this program remains low due to the poor access to PHC facilities, especially in outside Java region. There is a need to engage private sector, which makes up 60% of health facilities in Indonesia, to expand the coverage of NCD promotive and prevention activities.[31] Furthermore, the development of digital health solution for NCDs prevention and control should be included in the national COVID-19 plan.[32]

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Worldwide, disease-specific clinical guidelines are inadequate for the effective management of individuals with multimorbidity.[10,33] Although most countries and international health organizations have recognized the importance of multimorbidity (30), most health policies and programs still focus on single diseases. In Indonesia, current clinical practices and public health intervention largely focus on a single-disease framework. For example, Indonesia currently has no official clinical guideline to manage multimorbidity. Furthermore, under the current national health insurance scheme, the hospital reimbursement system that uses case-based groups has created significant gaps between reimbursable costs and actual hospital expenses.[34] The reimbursement system, which is mainly based on primary diagnosis, limits the hospital's capacity and willingness to treat complicated cases such as those with multimorbidity.[35] Thus, it is important to develop a clinical guideline for multimorbidity in Indonesia and other LMICs, along with payment systems that would ensure quality health services at both primary and secondary levels of care for patients with multimorbidity.

There are several limitations to our study. First, the IFLS-5 was conducted between 2014 and 2015, which may not able to capture current prevalence of multimorbidity in Indonesia. Despite this limitation, IFLS is the only longitudinal survey available in Indonesia that is useful to produce more accurate estimates compared with using cross-sectional dataset (e.g. the National Socioeconomic Survey). Second, our findings should be interpreted with causation since the assessment of chronic diseases was mostly based on self-reporting and may cause under-reporting of the prevalence. The health service use and OOP spending were also based on self-reporting and prone to recall bias.[36] Third, the IFLS sampling frame did not include Eastern regions of

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Indonesia. There is a need to extend the multimorbidity assessment to the remaining Indonesian regions. Fourth, this research intentionally focused on the older population due to a significantly higher burden of NCDs in this population group. Future research should use cohort data to follow patients over a longer time period to examine the impact of multimorbidity and its effects in younger population groups in LMICs.[13]

Conclusion

Multimorbidity poses substantial costs to individuals, households, health system and the wider society in Indonesia, which has an increasingly aging population. Policymakers and employers in Indonesia should carefully design and invest in targeted public health and workplace interventions at personal and population level to avert the adverse health and economic consequences of multimorbidity.

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Declarations

Abbreviation

CHE: Catastrophic health expenditure; HICs: High-income countries; IFLS: Indonesian Family Life Survey; LMICs: Low-middle income countries; NCDs: Noncommunicable diseases; OOPE: Out-of-pocket expenditure; PHC: Primary health care.

Competing interests

The authors have declared that no competing interests exist.

Ethics approval

The IFLS has been approved by ethics review boards at RAND Corporation and Gadjah Mada University in Indonesia. Written informed consent was sought from all respondents prior to data collection.

Author's contributions

Author's contributions: The aim of the research was developed by TM, KA, JL. The methodology development and analysis were conducted by TM, KA, HA, TP, JL. EH assisted in drafting the

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discussion section and proofread all section. YZ, HJ, MI contributed to background and discussion section. NN, BM, RA, JL provided critical input in revising the manuscript. All authors reviewed, edited and commented on multiple versions of the manuscript.

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Availability of data and materials

The datasets are publicly accessible after registration (https://www.rand.org/well-being/social-and-behavioral-policy/data/FLS/IFLS/access.html).

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Tables & Figures

Table 1. Sample characteristics and factors associated with multimorbidity

Characteristics	2007		2014		Factors associated with multimorbidity	
	Total n (%)	Multimorbidity % (95% CI)	Total n (%)	Multimorbidity % (95% CI)	aOR (95% CI)	p value
Overall	3678 (100%)	21.0 (19.6–22.6)	3678 (100%)	22.0 (20.6–23.6)		
Sex						
Male	1664 (46.1%)	14.1 (12.3–16.1)	1663 (46.0%)	19.4 (17.3–21.6)	1	
Female	2014 (53.9%)	26.9 (24.8–29.2)	2015 (54.0%)	24.3 (22.3–26.4)	1.74 (1.46–2.08)	<0.0001
Age						
50 – 60 years	2210 (59.8%)	19.9 (18.1–21.8)	966 (25.6%)	23.5 (20.7–26.7)	1	
61 – 70 years	1069 (29.9%)	21.9 (19.2–24.8)	1562 (42.9%)	21.6 (19.4–23.9)	1.10 (0.93–1.31)	0.257
71+ years	399 (10.3%)	25.2 (20.6–30.4)	1150 (31.4%)	21.4 (18.8–24.2)	1.09 (0.87–1.38)	0.444
Marital status						
Not currently married	927 (25.6%)	26.1 (23.0–29.4)	1338 (36.3%)	23.3 (20.9–25.9)	1	
Currently married	2751 (74.4%)	19.3 (17.7–21.1)	2340 (63.7%)	21.3 (19.5–23.2)	1.03 (0.86–1.24)	0.742
Educational level						
No education	2049 (58.7%)	20.4 (18.5–22.5)	2098 (60.6%)	18.0 (16.2–19.8)	1	
Primary	903 (24.8%)	19.7 (17.0–22.7)	862 (23.0%)	24.0 (20.9–27.3)	1.19 (0.98–1.44)	0.081
Junior high school	273 (6.4%)	25.9 (20.5–32.3)	271 (6.3%)	36.3 (30.2–43.0)	1.50 (1.12–2.02)	0.007
Senior high school	324 (7.2%)	20.5 (15.8–25.9)	307 (7.0%)	29.5 (24.1–35.5)	0.96 (0.71–1.29)	0.778
Tertiary	129 (2.9%)	34.4 (25.2–44.8)	140 (3.1%)	41.2 (31.6–51.6)	1.54 (1.01–2.34)	0.043
Ethnicity						
Javanese	1684 (51.8%)	19.4 (17.4–21.5)	1781 (55.8%)	19.7 (17.8–21.8)	1	
Sundanese	424 (15.9%)	29.1 (24.8–33.9)	438 (16.3%)	27.3 (23.1–31.8)	1.38 (1.08–1.77)	0.010
Others	1570 (32.3%)	19.6 (17.4–22.0)	1459 (27.9%)	23.6 (21.2–26.2)	1.10 (0.90–1.33)	0.355
Insurance coverage						
No	2652 (74.5%)	20.3 (18.6–22.1)	1950 (57.2%)	18.7 (16.9–20.7)	1	
Yes	1026 (25.5%)	23.2 (20.4–26.4)	1720 (42.8%)	26.4 (24.2–28.9)	1.18 (1.01–1.39)	0.035
Type of work						
Unemployed	951 (24.7%)	31.4 (28.1–34.9)	1483 (38.9%)	29.9 (27.4–32.6)	1	
Casual	674 (19.1%)	16.9 (13.9–20.4)	562 (14.1%)	13.8 (10.7–17.6)	0.47 (0.37–0.60)	<0.0001
Self-employed	1630 (45.2%)	16.8 (14.9–18.9)	1464 (40.1%)	17.4 (15.4–19.7)	0.61 (0.51–0.73)	<0.0001
Government/private	423 (10.9%)	22.2 (18.0–27.1)	269 (7.0%)	21.0 (15.8–27.4)	0.60 (0.45–0.79)	<0.0001
Per capita Household expenditure						
Q1 (the lowest)	728 (22.9%)	15.8 (13.0–18.9)	813 (25.2%)	13.5 (11.1–16.2)	1	
Q2	785 (22.4%)	17.9 (15.1–21.2)	746 (21.4%)	18.9 (15.9–22.3)	1.28 (1.01–1.62)	0.040
Q3	743 (20.1%)	20.5 (17.4–24.0)	757 (20.4%)	22.1 (18.9–25.7)	1.37 (1.08–1.74)	0.009
Q4	744 (18.4%)	23.6 (20.3–27.3)	681 (17.2%)	25.3 (21.9–29.0)	1.84 (1.44–2.33)	<0.0001
Q5 (the highest)	678 (16.1%)	30.4 (26.5–34.7)	681 (15.8%)	36.2 (32.2–40.5)	2.22 (1.72–2.86)	<0.0001
Residency						
Rural	1958 (63.4%)	18.1 (16.3–20.1)	1682 (52.8%)	16.9 (15.1–19.0)	1	
Urban	1720 (36.6%)	26.1 (23.8–28.6)	1996 (47.1%)	27.7 (25.5–30.0)	1.41 (1.19–1.67)	<0.0001
Region						
Java-Bali	2413 (77.5%)	21.6 (19.9–23.5)	2417 (77.6%)	21.1 (19.3–22.9)	1	
Sumatra	691 (14.5%)	19.6 (16.7–22.8)	690 (14.5%)	26.6 (23.3–30.2)	1.06 (0.85–1.33)	0.602
Nusa Tenggara	239 (2.4%)	14.5 (10.6–19.5)	239 (2.4%)	14.5 (10.5–19.6)	0.59 (0.40–0.87)	0.008
Kalimantan	168 (1.8%)	17.9 (12.7–24.5)	168 (1.7%)	34.2 (27.4–41.7)	1.35 (0.92–1.98)	0.129
Sulawesi	167 (3.8%)	19.6 (14.1–26.6)	164 (3.7%)	23.7 (17.6–31.0)	0.89 (0.59–1.34)	0.569

[a] Values are unweighted counts and weighted percentages unless otherwise indicated

[b] We defined multimorbidity if the respondents reported that they had 2 or more chronic conditions related to NCDs. Chronic diseases included: hypertension, diabetes, asthma, heart attack/coronary heart diseases, liver disease, stroke, cancer, arthritis/rheumatism, hypercholesterolemia, and mental illness.

[c] Adjusted odds ratio (aOR) was estimated using multilevel logistic regression model of 2007 and 2014 IFLS

NCD: non-communicable disease

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Table 2. Descriptive summary of health service use-financial burden and productivity outcomes by number of NCDs (2014 IFLS)

	No NCD	1 NCD	2 NCDs	+3 NCDs
	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
Overall (n, %)	1052 (100%)	1751 (100%)	627 (100%)	248 (100%)
Health service use				
Outpatient services [a)]				
Any visit (%, 95% CI)	15.5% (13.3–17.9)	21.7% (19.5–23.9)	35.7% (31.7–40.0)	55.9% (49.0–62.6)
Number of visits (mean, SD)	0.24 ± 0.72	0.41 ± 1.1	0.78 ± 1.6	1.4 ± 2.1
Inpatient services [b)]				
Any visit (%, 95% CI)	3.3% (2.3–4.8)	4.6% (3.5–6.0)	8.3% (6.1–11.0)	20.8% (15.7–27.0)
Number of visits (mean, SD)	0.04 ± 0.30	0.06 ± 0.31	0.14 ± 0.65	0.35 ± 0.96
Financial burden				
OOPE for outpatient care (mean, SD) [a,c)]	$17 ± 47	$17 ± 58	$15 ± 40	$60 ± 321
OOPE for inpatient care (mean, SD) [b,c)]	$566 ± 1,880	$527 ± 2,115	$792 ± 1,706	$762 ± 1,421
Annual Total OOPE (mean, SD)	$295 ± 977	$292 ± 1,239	$336 ± 950	$968 ± 4,313
Catastrophic health expenditure (%, 95% CI)				
>10% of total household expenditure	5.0% (3.7–6.6)	6.9% (5.6–8.5)	10.3% (7.9–13.4)	12.5% (8.7–17.7)
>25% of total household expenditure	1.5% (8.6–2.5)	1.5% (0.9–2.3)	2.8% (1.6–4.8)	2.8% (1.3–6.3)
>40% of total non-food expenditure	1.8% (1.1–2.8)	2.7% (1.9–3.6)	4.0% (2.6–6.2)	3.6% (1.8–6.8)
Productivity loss				
Labour participation (%, 95% CI)				
50-60 years[d)]	84.3% (79.8–88.0)	74.3% (69.3–7.8)	72.3% (64.3–79.1)	49.8% (36.7–62.9)
61-70 years [d)]	78.3% (74.0–82.1)	65.2% (61.1–69.1)	54.3% (47.1–61.3)	42.8% (32.6–53.8)
71+ years[d)]	51.4% (44.7–58.1)	45.0% (40.5–49.5)	28.4% (21.6–36.3)	17.3% (8.1–33.4)
Number of days of primary activity missed (mean, SD)	2.7 ± 6.0	3.6 ± 6.8	6.5 ± 9.8	10.1 ± 12.1
Number of days lying in bed (mean, SD)	0.80 ± 3.4	0.99 ± 3.6	1.9 ± 6.0	2.4 ± 6.3

[a)] in the last four weeks
[b)] in the last 12 months
[c)] Out-of-pocket expenditure (OOPE) were only asked to those who utilised outpatient and/or inpatient services.
[d)] The percentages were calculated based on the total number of respondents by aged groups. Total respondents aged 50-60 years, 61-70 years and 71+ years are 966, 1592, and 1150 respondents.
OOPE medical expenses were converted to 2014 International Dollars (INT$).
Bootstrapping with 400 times replications was performed to estimate the standard error and 95% CI.

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597 **Table 3. The effect of multimorbidity on health service use**

Variables	Health service use							
	Outpatient				Inpatient			
	Any visit[a)]		Number of visits[b)]		Any visit[a)]		Number of visits[b)]	
	aOR (95% CI)	p values	IRR (95% CI)	p values	aOR (95% CI)	p values	IRR (95% CI)	p values
Number of NCDs (ref. no NCD)								
Single NCD	1.35 (1.15–1.58)	<0.0001	1.45 (1.24–1.69)	<0.0001	1.07 (0.78–1.48)	0.671	1.06 (0.75–1.50)	0.755
Two NCDs	2.43 (2.00–2.95)	<0.0001	2.45 (2.04–2.93)	<0.0001	1.78 (1.23–2.57)	0.002	2.07 (1.39–3.08)	<0.0001
Three or more NCDs	4.66 (3.55–6.11)	<0.0001	4.25 (3.33–5.42)	<0.0001	3.69 (2.35–5.79)	<0.0001	3.68 (2.21–6.12)	<0.0001
Period (ref. 2007)								
2014	1.40 (1.22–1.61)	<0.0001	1.46 (1.29–1.65)	<0.0001	1.79 (1.36–2.36)	<0.0001	2.20 (1.63–2.98)	<0.0001
Sex (ref. Male)								
Female	1.26 (1.08–1.47)	0.003	1.20 (1.04–1.39)	0.013	0.93 (0.70–1.24)	0.626	0.85 (0.62–1.16)	0.300
Age (ref. 50 – 60 years)								
61 – 70 years	1.01 (0.86–1.18)	0.905	1.00 (0.87–1.16)	0.969	1.07 (0.78–1.45)	0.677	1.17 (0.84–1.65)	0.351
71+ years	1.10 (0.90–1.34)	0.351	1.06 (0.88–1.27)	0.567	1.49 (1.03–2.15)	0.034	1.66 (1.11–2.49)	0.014
Marital status (ref. Not married)								
Currently married	1.14 (0.97–1.34)	0.105	1.15 (0.99–1.34)	0.069	1.04 (0.77–1.40)	0.815	0.98 (0.71–1.37)	0.914
Educational level (ref. No education)								
Primary	1.06 (0.90–1.25)	0.496	0.96 (0.82–1.13)	0.629	1.09 (0.80–1.50)	0.578	0.97 (0.69–1.38)	0.882
Junior high school	1.04 (0.80–1.35)	0.786	1.00 (0.78–1.28)	0.993	1.23 (0.78–1.95)	0.368	1.48 (0.90–2.42)	0.120
Senior high school	1.05 (0.81–1.36)	0.706	0.91 (0.71–1.17)	0.473	0.91 (0.57–1.46)	0.699	0.82 (0.49–1.37)	0.448
Tertiary	1.29 (0.90–1.84)	0.167	0.93 (0.66–1.32)	0.697	0.98 (0.53–1.80)	0.937	0.85 (0.42–1.69)	0.640
Ethnicity (ref. Javanese)								
Sundanese	0.92 (0.74–1.14)	0.464	0.95 (0.77–1.16)	0.617	0.90 (0.61–1.34)	0.609	1.14 (0.75–1.76)	0.536
Others	1.06 (0.89–1.25)	0.525	0.99 (0.84–1.16)	0.877	0.90 (0.65–1.23)	0.495	1.08 (0.76–1.52)	0.676
Insurance coverage (ref. No)								
Yes	1.48 (1.28–1.70)	<0.0001	1.51 (1.32–1.72)	<0.0001	1.90 (1.45–2.50)	<0.0001	1.65 (1.23–2.21)	0.001
Type of work (ref. Unemployed)								
Casual	0.76 (0.62–0.95)	0.014	0.69 (0.57–0.85)	<0.0001	0.49 (0.31–0.78)	0.003	0.44 (0.27–0.73)	0.001
Self-employed	0.85 (0.73–1.00)	0.056	0.82 (0.70–0.95)	0.008	0.60 (0.44–0.82)	0.001	0.60 (0.43–0.83)	0.002
Government/private	0.75 (0.58–0.96)	0.025	0.72 (0.57–0.92)	0.008	0.63 (0.39–1.04)	0.071	0.77 (0.46–1.31)	0.335
Per capita household expenditure (ref. Q1)								
Q2	1.50 (1.21–1.86)	<0.0001	1.50 (1.23–1.84)	<0.0001	1.25 (0.81–1.92)	0.307	1.07 (0.67–1.70)	0.777
Q3	1.76 (1.42–2.18)	<0.0001	1.74 (1.42–2.13)	<0.0001	1.64 (1.08–2.49)	0.020	1.71 (1.10–2.66)	0.018
Q4	1.73 (1.38–2.15)	<0.0001	1.80 (1.46–2.21)	<0.0001	1.42 (0.91–2.20)	0.121	1.36 (0.86–2.18)	0.192
Q5	1.90 (1.51–2.40)	<0.0001	2.09 (1.68–2.59)	<0.0001	2.48 (1.60–3.85)	<0.0001	2.52 (1.59–4.00)	<0.0001
Residency (ref. Rural)								
Urban	0.92 (0.80–1.07)	0.283	0.95 (0.83–1.10)	0.500	0.96 (0.72–1.26)	0.744	1.05 (0.78–1.42)	0.726
Region (ref. Java-Bali)								
Sumatra	0.83 (0.68–1.00)	0.052	0.98 (0.81–1.17)	0.798	1.23 (0.87–1.74)	0.236	1.25 (0.86–1.82)	0.250
Nusa Tenggara	0.64 (0.46–0.89)	0.007	0.60 (0.43–0.82)	0.002	1.25 (0.71–2.18)	0.437	1.11 (0.60–2.03)	0.745
Kalimantan	1.03 (0.74–1.43)	0.873	1.21 (0.89–1.65)	0.228	1.09 (0.58–2.05)	0.799	0.94 (0.47–1.89)	0.865
Sulawesi	0.64 (0.45–0.93)	0.019	0.63 (0.44–0.90)	0.011	0.63 (0.30–1.35)	0.235	0.63 (0.29–1.38)	0.249

[a)] Multilevel logistic regression model

[b)] Multilevel negative binomial regression model

aOR: adjusted odds ratio, IRR: Incidence rate ratio, NCD: non-communicable disease

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599 **Table 4. The effect of multimorbidity on catastrophic expenditure**

Variables	Catastrophic health expenditure					
	10% of total household expenditure[a)]		25% of total household expenditure[a)]		40% of non-food expenditure [a)]	
	aOR (95% CI)	p values	aOR (95% CI)	p values	aOR (95% CI)	p values
Number of NCDs (ref. no NCD)						
Single NCD	1.11 (0.76–1.62)	0.591	0.81 (0.49–1.34)	0.417	0.86 (0.52–1.43)	0.561
Two NCDs	1.58 (1.06–2.35)	0.026	1.39 (0.79–2.45)	0.250	1.27 (0.69–2.35)	0.437
Three or more NCDs	1.69 (1.02–2.81)	0.042	0.96 (0.40–2.34)	0.937	0.72 (0.27–1.89)	0.503
Period (ref. 2007)						
2014	1.42 (1.12–1.80)	0.003	1.27 (0.83–1.95)	0.271	1.18 (0.77–1.80)	0.442
Sex (ref. Male)						
Female	0.89 (0.64–1.23)	0.480	0.90 (0.57–1.42)	0.645	0.83 (0.52–1.33)	0.432
Age (ref. 50 – 60 years)						
61 – 70 years	1.15 (0.79–1.69)	0.461	1.46 (0.90–2.36)	0.125	1.43 (0.85–2.38)	0.175
71+ years	1.13 (0.66–1.92)	0.663	1.01 (0.51–2.01)	0.975	1.24 (0.60–2.55)	0.563
Marital status (ref. Not married)						
Currently married	1.59 (1.22 – 2.09)	0.001	1.68 (0.98–2.87)	0.060	1.83 (1.01–3.33)	0.047
Educational level (ref. No education)						
Primary	0.96 (0.67–1.38)	0.841	0.90 (0.52–1.55)	0.708	0.85 (0.48–1.52)	0.589
Junior high school	0.97 (0.64–1.47)	0.902	1.21 (0.58–2.55)	0.610	0.60 (0.25–1.48)	0.271
Senior high school	0.93 (0.61–1.42)	0.735	1.22 (0.59–2.52)	0.595	0.81 (0.34–1.92)	0.627
Tertiary	0.45 (0.22–0.90)	0.023	0.11 (0.01–0.94)	0.043	0.12 (0.02–0.84)	0.032
Ethnicity (ref. Javanese)						
Sundanese	0.87 (0.62–1.23)	0.433	1.80 (0.98–3.33)	0.060	1.14 (0.52–2.48)	0.748
Others	0.76 (0.56–1.02)	0.065	1.01 (0.58–1.78)	0.959	0.56 (0.28–1.09)	0.088
Insurance coverage (ref. No)						
Yes	0.89 (0.67–1.20)	0.451	0.83 (0.53–1.31)	0.425	0.80 (0.49–1.32)	0.390
Type of work (ref. Unemployed)						
Casual	0.59 (0.33–1.07)	0.082	0.58 (0.29–1.17)	0.128	0.41 (0.20–0.84)	0.015
Self-employed	0.60 (0.36–1.01)	0.056	0.58 (0.35–0.96)	0.033	0.45 (0.27–0.76)	0.003
Government/private	0.58 (0.34–1.02)	0.058	0.78 (0.35–1.70)	0.527	0.39 (0.16–0.95)	0.038
Per capita household expenditure (ref. Q1)						
Q2	1.04 (0.071- 1.52)	0.834	1.60 (0.71–3.57)	0.257	1.34 (0.62–2.90)	0.459
Q3	1.37 (0.97–1.95)	0.076	1.71 (0.77–3.80)	0.188	1.19 (0.54–2.61)	0.669
Q4	1.98 (1.40–2.81)	<0.0001	3.11 (1.43–6.76)	0.004	2.73 (1.23–6.03)	0.013
Q5	3.13 (2.28–4.31)	<0.0001	5.91 (2.72–12.85)	<0.0001	8.45 (3.70–19.32)	<0.0001
Residency (ref. Rural)						
Urban	0.94 (0.61–1.45)	0.785	0.76 (0.46–1.24)	0.273	0.75 (0.43–1.31)	0.309
Region (ref. Java-Bali)						
Sumatra	0.78 (0.56–1.09)	0.146	0.73 (0.38–1.38)	0.328	1.08 (0.52–2.24)	0.846
Nusa Tenggara	0.64 (0.34 – 1.21)	0.175	0.98 (0.32–2.99)	0.968	0.93 (0.22–3.83)	0.917
Kalimantan	0.78 (0.39–1.52)	0.460	0.64 (0.19–2.24)	0.488	0.64 (0.15–2.77)	0.548
Sulawesi	0.80 (0.43–1.48)	0.478	1.21 (0.41–3.57)	0.724	1.31 (0.33–5.17)	0.701

[a)] Multilevel logistic regression model

aOR: adjusted odds ratio, NCD: non-communicable diseass

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Table 5. The effect of multimorbidity on productivity loss

Variables	Productivity loss					
	Labour participation[a)]		Days primary activity missed[b)]		Days stayed in bed[b)]	
	aOR (95% CI)	p values	IRR (95% CI)	p values	IRR (95% CI)	p values
Number of NCDs (ref. no NCD)						
Single NCD	0.65 (0.54–0.79)	<0.0001	1.25 (1.08–1.43)	0.002	1.09 (0.84–1.43)	0.509
Two NCDs	0.45 (0.35–0.57)	<0.0001	1.90 (1.58–2.29)	<0.0001	1.87 (1.33–2.61)	<0.0001
Three or more NCDs	0.23 (0.16–0.33)	<0.0001	2.59 (1.97–3.41)	<0.0001	2.64 (1.60–4.36)	<0.0001
Period (ref. 2007)						
2014	0.69 (0.59–0.81)	<0.0001	1.66 (1.46–1.88)	<0.0001	1.79 (1.40–2.29)	<0.0001
Sex (ref. Male)						
Female	0.21 (0.17–0.26)	<0.0001	0.99 (0.86–1.14)	0.912	0.92 (0.70–1.21)	0.567
Age (ref. 50 – 60 years)						
61 – 70 years	0.37 (0.31–0.45)	<0.0001	0.99 (0.86–1.14)	0.859	1.07 (0.81–1.41)	0.617
71+ years	0.10 (0.07–0.13)	<0.0001	1.20 (1.00–1.44)	0.047	1.93 (1.37–2.72)	<0.0001
Marital status (ref. Not married)						
Currently married	1.51 (1.23–1.84)	<0.0001	1.13 (0.98–1.31)	0.089	0.88 (0.67–1.17)	0.395
Educational level (ref. No education)						
Primary	0.89 (0.71–1.11)	0.305	0.92 (0.79–1.07)	0.263	1.00 (0.75–1.33)	0.999
Junior high school	0.41 (0.29–0.57)	<0.0001	0.94 (0.74–1.20)	0.631	0.87 (0.54–1.40)	0.570
Senior high school	0.41 (0.29–0.58)	<0.0001	0.68 (0.53–0.87)	0.002	0.81 (0.51–1.28)	0.362
Tertiary	0.51 (0.31–0.82)	0.006	0.54 (0.38–0.78)	0.001	0.37 (0.18–0.78)	0.009
Ethnicity (ref. Javanese)						
Sundanese	0.50 (0.37–0.67)	<0.0001	1.35 (1.11–1.65)	0.003	1.28 (0.89–1.85)	0.179
Others	0.77 (0.61–0.98)	0.033	1.11 (0.95–1.30)	0.188	1.12 (0.84–1.49)	0.436
Insurance coverage (ref. No)						
Yes	0.85 (0.72–1.01)	0.071	1.08 (0.95–1.22)	0.258	1.05 (0.82–1.34)	0.704
Type of work (ref. Unemployed)						
Casual	N/A	N/A	0.62 (0.51–0.75)	<0.0001	0.32 (0.22–0.47)	<0.0001
Self-employed	N/A	N/A	0.62 (0.53–0.71)	<0.0001	0.42 (0.32–0.56)	<0.0001
Government/private	N/A	N/A	0.57 (0.45–0.72)	<0.0001	0.45 (0.28–0.73)	0.001
Per capita household expenditure (ref. Q1)						
Q2	1.37 (1.08–1.75)	0.011	1.03 (0.86–1.23)	0.744	1.05 (0.74–1.49)	0.769
Q3	1.33 (1.03–1.71)	0.028	1.15 (0.96–1.38)	0.130	1.06 (0.75–1.50)	0.737
Q4	1.12 (0.87–1.46)	0.379	1.05 (0.87–1.27)	0.627	1.02 (0.71–1.46)	0.914
Q5	1.34 (1.01–1.77)	0.043	1.29 (1.05–1.58)	0.015	0.92 (0.63–1.35)	0.668
Residency (ref. Rural)						
Urban	0.44 (0.35–0.54)	<0.0001	0.93 (0.81–1.07)	0.296	0.70 (0.54–0.89)	0.004
Region (ref. Java-Bali)						
Sumatra	0.95 (0.73–1.25)	0.735	1.13 (0.94–1.36)	0.194	1.01 (0.73–1.40)	0.956
Nusa Tenggara	0.74 (0.48–1.14)	0.177	0.90 (0.68–1.20)	0.472	1.14 (0.67–1.93)	0.638
Kalimantan	1.21 (0.75–1.94)	0.440	0.90 (0.67–1.22)	0.511	0.89 (0.51–1.57)	0.688
Sulawesi	0.39 (0.24–0.62)	<0.0001	0.99 (0.72–1.36)	0.948	0.94 (0.53–1.69)	0.845

[a)] Multilevel logistic regression model
[b)] Multilevel negative binomial regression model
aOR: adjusted odds ratio, IRR: incidence rate ratio, NCD: non-communicable disease

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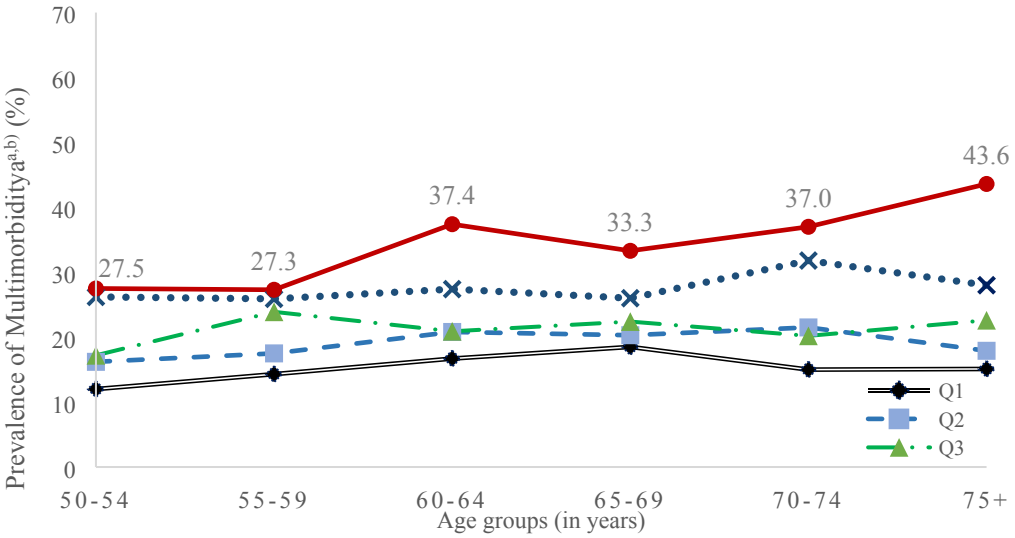
Figure 1. Prevalence of multimorbidity by age group and per capita household expenditure



[a)] respondents who reported that they had 2 or more chronic conditions related to non-communicable diseases (NCDs). [b)] Pooled sample of Wave 4 and Wave 5. Q1-Q5 refer to household expenditure quintiles, where Q1 is the lowest and Q5 the highest household expenditure quintile.

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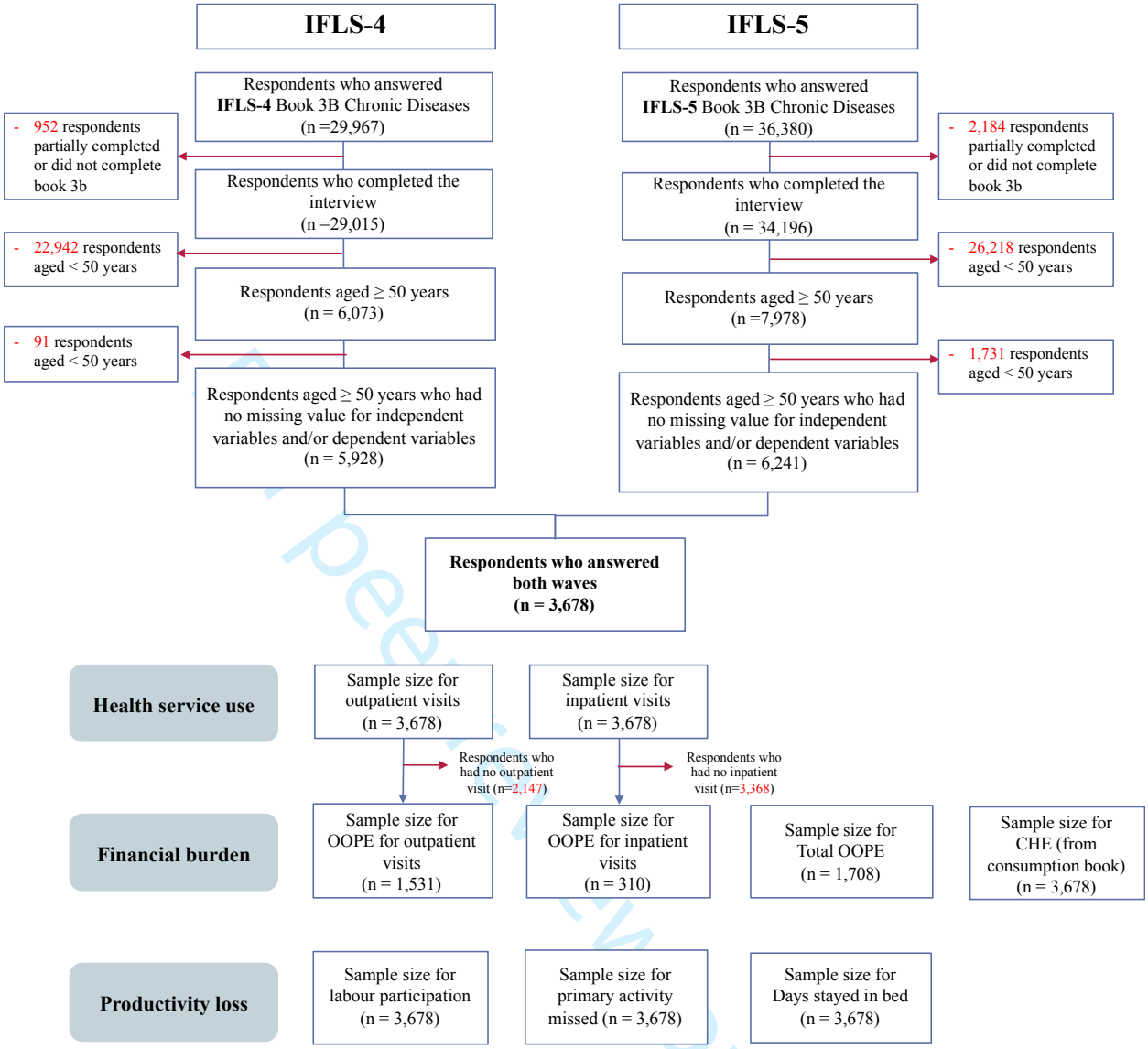
Figure S1. Sample flowchart



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613 **Table S1. STROBE Statement**

	Item	Recommendation	Reported on page	Relevant text from manuscript
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	2	"Panel Data Analysis"
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	3	"Multimorbidity is associated with substantial direct and indirect costs to individuals, households, and the wider society."
Introduction				
Backgroun d/rationale	2	Explain the scientific background and rationale for the investigation being reported	4, 5	"Evidence from high-income countries (HICs) has found that…"
Objectives	3	State specific objectives, including any prespecified hypotheses	5,6	"to examine multimorbidity levels, and their relation to households' socioeconomic characteristics, health service use, catastrophic health expenditures, and productivity loss."
Methods				
Study design	4	Present key elements of study design early in the paper	6	"The study used panel data from two waves of the Indonesian Family Life Survey (IFLS)."
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	6	"Waves 5 was conducted between September 2014–March 2015."
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	6	"We included respondents aged 50 years and above in 2014, excluded those who did not participate in both Waves 4 and 5, and those with missing values for the study variable."
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case		N/A
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	7–9	In "variables" subsection.
Data sources/	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of	7–9	In "variables" subsection. Details of the

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	Item	Recommendation	Reported on page	Relevant text from manuscript
measurement		assessment methods if there is more than one group		measurements are available in Table S2
Bias	9	Describe any efforts to address potential sources of bias	10	"Taking into account the hierarchical (nested) nature of the dataset (i.e. observations nested within individuals, and individuals nested within households, and districts), a multilevel level model approach was used."
Study size	10	Explain how the study size was arrived at	10	Our final sample is 3,678 respondents (the sample flowchart is presented in Figure S1).
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	7	In "variables" subsection, i.e. "A total of 10 NCDs were used to quantify the number of NCDs (0, 1, 2, 3 or more) and respondents with two or more NCDs were categorized as having multimorbidity (categorized as 0 or 1)"
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	10	In "statistical analysis" subsection. For example "…, adjusting for covariates"
		(*b*) Describe any methods used to examine subgroups and interactions	10	"We described the patterns of multimorbidity across different population subgroups…"
		(*c*) Explain how missing data were addressed	7	"…excluded those who did not participate in both Waves 4 and 5, and those with missing values for the study"
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy	7	"…excluded those who did not participate in both Waves 4 and 5, and those with missing values for the study"
		(*e*) Describe any sensitivity analyses	10	"We conducted two robustness analyses."
Results				
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	32	Figure S1: Sampling flow chart

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	Item	Recommendation	Reported on page	Relevant text from manuscript
		(b) Give reasons for non-participation at each stage	32	Figure S1: Sampling flow chart
		(c) Consider use of a flow diagram	32	Figure S1: Sampling flow chart
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	32	Figure S1: Sampling flow chart
		(b) Indicate number of participants with missing data for each variable of interest	32	Figure S1: Sampling flow chart
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	32	Figure S1: Sampling flow chart
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	26	Table 1 and Table 2
		Case-control study—Report numbers in each exposure category, or summary measures of exposure		N/A
		Cross-sectional study—Report numbers of outcome events or summary measures		
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	27–30	Table 2 – Table 5. For example, "Respondents with a single NCD were 1·61 times more likely (95% CI 1·21-2·14) to have experienced an outpatient visit in the past four weeks compared to those without an NCD."
		(*b*) Report category boundaries when continuous variables were categorized	37–38	Table S2: List of variables for 2007 and 2014 IFLS analyses
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period		N/A
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	42–47	Tables S6–11. For example, "Our robustness analysis using cross-sectional analysis using 2014 cross-sectional dataset that consists of 14 physical NCDs (Tables S6–8) showed consistent results"
Discussion				

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	Item	Recommendation	Reported on page	Relevant text from manuscript
Key results	18	Summarise key results with reference to study objectives	16	"Multimorbidity was associated with higher use of healthcare services, higher probability of catastrophic health expenditure, and a reduction in productivity."
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	18–19	"There are several limitations to our study."
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	18–19	"Our findings should be interpreted with causation since the assessment of chronic diseases was mostly based on self-reporting and may cause under- or over-reporting of the prevalence"
Generalisability	21	Discuss the generalisability (external validity) of the study results	19	"This research intentionally focused on the older population due to a significantly higher burden of NCDs in this population group."
Other information				
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	20	Funding "This research received no specific grant from any funding agency in the public, commercial or not-for-profit sectors"

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Table S2. List of variables for 2007 & 2014 IFLS analysis

Variables	Type	Measurement	Source of measurement
Dependent variables:			
1) Health service use			
Outpatient care	Binary	0. No 1. Yes	RJ00: In the last 4 weeks have you visited a public hospital-*puskesmas*-private hospital-clinic-health worker or doctor's practice or been visited by a health worker or doctor?
	Numerical	Number of days	RJ02: How many times did you visit / been visited by [...] during the last 4 weeks?
Inpatient care	Binary	0. No 1. Yes	RN00: During the past 12 months have you ever received patient care at a hospital-*puskesmas*-clinic-or other?
	Numerical	Number of days	RN02: How many times have you received inpatient care at […] during the past 12 months?
2) Productivity loss			
Labour participation	Binary	0. No 1. Yes	TK06a: Did you work/try to work/help to earn income for pay for at least 1 hour during the past week?
	Numerical	Number of days	
Activity missed due to poor health	Numerical	Number of days	KK02a: During the last 4 weeks-how many days of your primary daily activities did you miss due to poor health?
Stayed in bed	Numerical	Number of days	KK02b: In the last 4 weeks-how many days have you stayed in bed due to poor health?
3) Financial burden			
OOPE of outpatient care	Numerical	International Dollars	RJ02b: How much did you pay out of pocket for outpatient care at […] during the past 4 weeks?
OOPE of inpatient care	Numerical	International Dollars	RN02b: How much did you pay out of pocket for inpatient care at […] during the past 12 months?
Annual Total OOPE	Numerical	International Dollars	Annual total OOPE for outpatient and inpatient visits
Catastrophic health expenditure	Binary	0. No 1. Yes	Book KS: "How much money spent by all household members for medical costs during the past year?"
Main independent variable			
Number of NCDs	Numerical	Total number of chronic conditions related to NCDs	Book IIIB: CD06a – CD06r: Have a doctor/paramedic/nurse/ midwife ever told you that you had [list of chronic diseases]
	Categorical ordinal	2. No 3. 1 NCD	

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Variables	Type	Measurement	Source of measurement
		4. 2 NCDs 5. 3+ NCDs	
Multimorbidity	Binary	0. No 1. Yes (had 2 or more chronic conditions related to NCDs)	Book IIIB: CD06a – CD06r: Have a doctor/paramedic/nurse/ midwife ever told you that you had [list of chronic diseases]
List of chronic diseases included in the main analysis: Hypertension, diabetes, asthma, heart attack/coronary heart diseases, liver disease, stroke, cancer, arthritis/rheumatism, hypercholesterolemia, and depression/mental illness. List of chronic diseases in 2007 IFLS (Wave 4): Hypertension, diabetes, asthma, heart attack/coronary heart diseases, liver disease, stroke, cancer, arthritis/rheumatism, hypercholesterolemia, and depression/mental illness. List of chronic diseases in 2014 IFLS (Wave 5): Hypertension, diabetes, asthma, heart attack/coronary heart diseases, liver disease, stroke, cancer, arthritis/rheumatism, hypercholesterolemia, mental illness, prostate diseases, kidney diseases (excluding malignancy), digestive diseases, and memory-related diseases.			
Covariates			
Age (in years)	Categorical ordinal	0. 40-49 years 1. 50-59 years 2. 60-69 years 3. 70-79 years 4. 80+	Book IIIA: Age: How old are you?
Sex	Binary	0. Male 1. Female	Book IIIA: Sex: (identified by interviewers)
Ethnicity	Categorical nominal	0. Javanese 1. Sundanese 2. Others	
Marital status	Binary	0. Unmarried/Divorce 1. Married or living together	Book IIIA HR00b: Are you currently married?
Education	Categorical ordinal	0. None 1. Elementary school 2. Junior high school 3. High school 4. Tertiary	Book IIIA: DL06: What is the highest education level attended? DL07: What is the highest grade completed at school.
Occupation	Categorical nominal	0. None 1. Casual worker 2. Self-employed 3. Government/private worker	Book IIIA: TK06a: Did you work/try to work/help to earn income for pay for at least 1 hour during the past week? TK15: Which category best describes the work you did in your last job?
Health insurance status	Binary	0. Uninsured (Not covered by any insurance) 1. Insured	Book IIIB: AK01: Are you the policy holder/primary beneficiary of health benefits-health insurance?
Per capita expenditure	Categorical ordinal	0. Q1 (lowest) 1. Q2 2. Q3 3. Q4 4. Q5 (highest)	Book KS
Residency	Binary	0. Rural 1. Urban	Book T-2: SC06: (identified by interviewers)
Region	Categorical nominal	0. Java-Bali 1. Sumatra 2. Nusa Tenggara 3. Kalimantan 4. Sulawesi	Book T-2: SC01: province (identified by interviewers)

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617 **Table S3. Sample characteristics by number of NCDs**

Characteristics	2007 (n=3,678)			2014 (n=3,678)		
	Zero NCD (n=1,272)	One NCD (n=1,605)	Multimorbidity (n=801)	Zero NCD (n=1,052)	One NCD (n=1,751)	Multimorbidity (n=875)
Sex						
Male	44.2 (41.5–46.9)	41.7 (39.1–44.5)	14.1 (12.3–16.1)	34.7 (32.1–37.3)	45.9 (43.2–48.7)	19.3 (17.3–21.6)
Female	28.9 (26.7–31.3)	44.2 (41.7–46.7)	26.9 (24.8–29.2)	24.6 (22.5–26.8)	51.1 (48.6–53.6)	24.3 (22.3–26.4)
Age						
50 – 60 years	39.9 (37.55–42.2)	40.3 (38.0–42.6)	19.9 (18.1–21.8)	36.4 (33.0–39.9)	40.1 (36.6–43.7)	23.5 (20.7–26.7)
61 – 70 years	32.3 (29.1–35.6)	45.9 (42.5–49.3)	21.9 (19.2–24.8)	30.2 (27.7–32.9)	48.2 (45.4–51.0)	21.6 (19.4–23.9)
71+ years	23.9 (19.2–29.3)	50.9 (45.2–56.6)	25.2 (20.6–30.4)	22.0 (19.4–25.0)	56.6 (53.2–59.8)	21.4 (18.8–24.2)
Marital status						
Not currently married	25.6 (22.5–29.0)	48.3 (44.6–52.0)	26.1 (23.0–29.4)	23.8 (21.2–26.5)	52.9 (49.9–56.0)	23.3 (20.9–25.9)
Currently married	39.5 (37.4–41.6)	41.2 (39.1–43.4)	19.3 (17.7–21.1)	32.4 (30.2–34.6)	46.3 (44.0–48.7)	21.3 (19.5–23.2)
Educational level						
No education	24.8 (32.5–37.2)	44.8 (42.3–47.2)	20.4 (18.5–22.5)	29.6 (27.4–31.9)	52.4 (50.0–54.8)	18.0 (16.2–19.8)
Primary	40.5 (36.9–44.2)	39.8 (36.2–46/3)	19.7 (17.0–22.7)	28.6 (25.3–32.1)	47.5 (43.7–51.3)	24.0 (20.9–27.3)
Junior high school	34.4 (28.3–41.1)	39.6 (33.4–46.3)	25.9 (20.5–32.3)	31.6 (25.6–38.3)	32.1 (26.1–38.7)	36.3 (30.2–43.0)
Senior high school	35.9 (30.2–42.1)	43.6 (37.5–49.8)	20.5 (15.8–25.9)	28.9 (23.4–35.0)	41.6 (35.6–48.0)	29.5 (24.1–35.5)
Tertiary	23.7 (16.2–33.2)	41.9 (32.1–52.4)	34.4 (25.2–44.8)	23.0 (15.8–32.2)	35.7 (27.0–45.5)	41.2 (31.6–51.6)
Ethnicity						
Javanese	37.0 (34.5–39.6)	43.6 (41.0–46.2)	19.4 (17.4–21.5)	29.7 (27.4–32.1)	50.6 (48.1–53.2)	19.7 (17.8–21.8)
Sundanese	30.4 (25.9–35.2)	40.5 (35.7–45.5)	29.1 (24.8–33.9)	23.5 (19.6–27.9)	49.3 (44.3–54.2)	27.3 (23.1–31.8)
Others	37.0 (34.2–39.9)	43.4 (40.5–46.3)	19.6 (17,4–22.0)	31.7 (29.0–34.7)	44.6 (41.6–47.7)	23.6 (21.2–26.2)
Insurance coverage						
No	36.5 (34.4–38.6)	43.2 (41.1–45.4)	20.3 (18.6–22.1)	31.1 (28.9–33.5)	50.2 (47.7–52.7)	18.7 (16.9–20.7)
Yes	34.2 (30.9–37.7)	42.5 (39.1–46.0)	23.2 (20.4–26.4)	26.7 (24.3–29.2)	46.8 (44.1–49.6)	26.4 (24.2–28.9)
Type of work						
Unemployed	22.5 (19.6–25.6)	46.2 (42.6–49.8)	31.4 (28.1–34.9)	19.6 (17.4–22.1)	50.4 (47.5–53.3)	29.9 (27.4–32.6)
Casual	41.8 (37.6–46.1)	41.3 (37.2–45.6)	16.9 (13.9–20.4)	36.5 (31.6–41.6)	49.7 (44.6–54.8)	13.8 (10.7–17.6)
Self-employed	41.1 (38.4–43.9)	42.1 (39.4–44.8)	16.8 (14.9–18.9)	34.2 (31.5–37.0)	48.4 (45.4–51.3)	17.4 (15.4–19.7)
Government/private	34.8 (29.8–40.2)	43.0 (37.7–48.4)	22.2 (18.0–27.1)	39.6 (33.0–46.5)	39.4 (32.9–46.3)	21.0 (15.8–27.4)
Household expenditure						
Q1 (the lowest)	39.9 (36.0–43.9)	44.1 (40.1–48.1)	15.8 (13.0–18.9)	30.9 (27.5–34.6)	55.6 (51.8–59.3)	13.5 (11.1–16.2)
Q2	39.6 (35.7–43.6)	42.4 (38.6–46.4)	17.9 (15.1–21.2)	31.6 (27.9–35.5)	49.5 (45.4–53.6)	18.9 (15.9–22.3)
Q3	36.4 (32.5–40.5)	43.1(39.1–47.2)	20.5 (17.4–24.0)	31.4 (27.7–35.3)	46.5 (42.5–50.6)	22.1 (18.9–25.7)
Q4	31.7 (27.9–35.7)	44.6 (40.5–48.7)	23.6 (20.3–27.3)	27.0 (23.3–31.1)	47.8 (43.4–52.1)	25.3 (21.9–29.0)
Q5 (the highest)	28.8 (24.9–33.0)	40.5 (36.3–44.9)	30.4 (26.5–34.7)	23.1 (19.6–27.0)	40.7 (36.5–45.0)	36.2 (32.2–40.5)
Residency						
Rural	38.7 (36.3–41.1)	43.2 (40.8–45.7)	18.1 (16.3–20.1)	31.0 (28.6–33.5)	52.1 (49.4–54.7)	16.9 (15.1–19.0)
Urban	31.2 (28.7–33.7)	42.7 (40.1–45.4)	26.1 (23.8–28.6)	27.3 (25.1–29.6)	45.0 (42.5–47.5)	27.7 (25.5–30.0)
Island						
Java-Bali	36.5 (34.4–38.7)	41.9 (39.7–44.1)	21.6 (19.9–23.5)	29.7 (27.7–31.7)	49.3 (47.1–51.5)	21.1 (19.3–22.9)
Sumatra	34.6 (31.0–38.4)	45.9 (42.0–49.8)	19.6 (16.7–22.8)	27.9 (24.6–31.6)	45.4 (41.6–49.4)	26.6 (23.3–30.2)
Nusa Tenggara	44.0 (37.7–50.5)	41.6 (35.3–48.1)	14.5 (10.6–19.5)	31.4 (25.7–37.7)	54.1 (47.6–60.5)	14.5 (10.5–19.6)
Kalimantan	25.2 (19.2–32.4)	56.9 (49.0–64.4)	17.9 (12.7–24.5)	23.4 (17.6–30.6)	42.4 (35.0–50.1)	34.2 (27.4–41.7)
Sulawesi	30.0 (23.3–37.6)	50.4 (42.6–58.2)	19.6 (14.1–26.6)	26.7 (20,3–34.2)	49.7 (41.8–57.5)	23.7 (17.6–31.0)
Overall (N, %)	1,272 (35.9)	1,605 (43.0)	801 (21.0)	1,052 (29.2)	1,751 (48.7)	875 (22.0)

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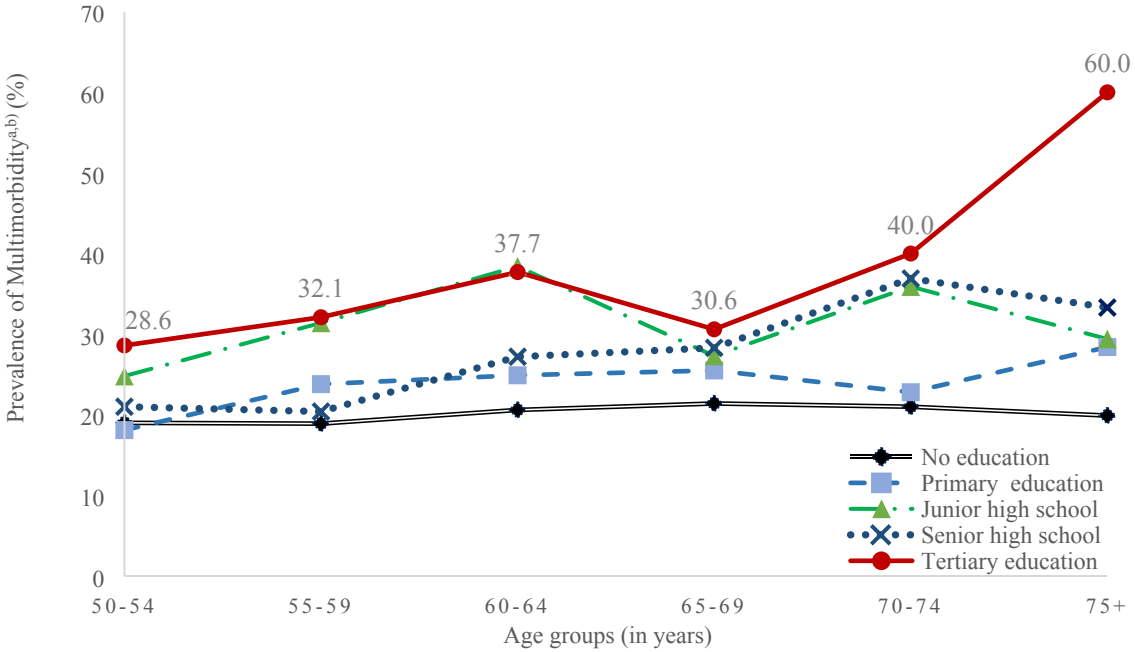
Figure S2. Prevalence of multimorbidity by age group and level of education



[a)] respondents who reported that they had 2 or more chronic conditions related to non-communicable diseases (NCDs). [b)] Pooled sample of Wave 4 and Wave 5.

Table S4. Intraclass correlation coefficients (ICC) on multimorbidity, health service use and labour participation

	Multimorbidity	Any outpatient visit	Any inpatient visit	10% of total household expenditure	25% of total household expenditure	40% of non-food expenditure	Labour participation
Individual							
Variance (SE)	1.09 (0.25)	0.10 (0.18)	0.57 (0.74)	0 (0)	0 (0)	0 (0)	1.22 (0.30)
ICC (SE)	0.34 (0.03)	0.14 (0.03)	0.25 (0.12)	0.25 (0.03)	0.48 (0.04)	0.69 (0.04)	0.48 (0.03)
Household							
Variance (SE)	0.64 (0.20)	0.43 (0.14)	0.54 (0.57)	1.13 (0.20)	3.08 (0.55)	7.29 (1.3)	1.70 (0.28)
ICC (SE)	0.13 (0.40)	0.11 (0.04)	0.12 (0.12)	0.25 (0.03)	0.48 (0.04)	0.69 (0.04)	0.28 (0.04)
District							
Variance (SE)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.07 (0.04)
ICC (SE)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.01 (0.01)

Note:
All models are controlled for study variables, including sex, age, marital status, education, ethnicity, insurance coverage, type of work, per capita expenditure (PCE), residency, and region. SE: standard error. ICC: intraclass correlation

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Table S5. Robustness check: descriptive summary and factors associated with multimorbidity (cross-sectional analysis of 2014 IFLS)

Characteristics	Weighted % Of sample	Zero NCD (%, 95% CI)	One NCD (%, 95% CI)	Two NCDs (%, 95% CI)	Three or more NCDs (%, 95% CI)	Multimorbidity[b] (%, 95% CI)	Multimorbidity[b] aOR (95% CI)
Sex							
Female	51.9	24.8 (22.3, 26.3)	46.1 (44.4, 47.8)	18.8 (17.5, 20.1)	10.3 (9.3, 11.4)	29.1 (27.6, 30.6)	1
Male	48.1	36.5 (34.7, 38.3)	42.0 (40.2, 43.9)	14.0 (12.8, 15.4)	7.4 (6.5, 8.4)	21.5 (20.0, 23.0)	0.68*** (0.59–0.78)
Age							
50 – 60 years	56.2	35.3 (33.7, 37.1)	41.0 (39.3, 42.7)	15.2 (14.0, 16.5)	8.5 (7.6, 9.5)	23.7 (22.8, 25.2)	1
61 – 70 years	25.6	26.5 (24.4, 28.8)	45.4 (42.9, 47.9)	17.7 (15.9, 19.6)	10.4 (9.0, 11.9)	28.1 (25.6, 30.3)	1.23*** (1.10–1.42)
71+ years	18.2	20.8 (18.6, 23.3)	52.2 (49.4, 55.1)	18.8 (16.7, 21.0)	8.2 (6.8, 9.8)	26.9 (24.6, 29.5)	1.85 (0.99–1.42)
Marital status							
Not currently married	28.2	24.7 (22.7, 26.8)	46.9 (44.6, 49.2)	19.3 (17.5, 21.2)	9.1 (8.0, 10.5)	28.4 (26.4, 30.5)	1
Currently married	71.8	32.7 (31.3, 34.1)	43.1 (41.6, 44.6)	15.4 (14.4, 16.5)	8.8 (8.0, 9.7)	24.2 (23.0, 25.5)	1.05 (0.89–1.21)
Educational level							
No education	53.3	31.3 (29.7, 33.0)	47.7 (45.9, 49.4)	14.1 (13.0, 15.4)	6.9 (6.1, 7.8)	21.0 (19.7, 22.4)	1
Primary	23.8	30.0 (27.6, 32.4)	42.8 (40.2, 45.4)	18.2 (16.3, 20.3)	9.0 (7.7, 10.6)	27.2 (25.0, 29.6)	1.35*** (1.16–1.57)
Junior high school	7.8	30.9 (27.0, 35.1)	34.8 (30.7, 39.1)	20.2 (16.9, 23.9)	14.2 (11.4, 17.5)	34.4 (30.3, 38.6)	1.66*** (1.33–2.06)
Senior high school	10.0	30.4 (26.9, 34.1)	38.7 (35.0, 42.6)	18.0 (15.3, 21.1)	12.8 (10.4, 15.7)	30.9 (27.4, 34.5)	1.23 (0.99–1.53)
Tertiary	5.1	22.8 (18.5, 27.8)	38.7 (33.5, 44.2)	24.4 (20.0, 29.4)	14.1 (10.6, 18.4)	38.4 (33.3, 43.9)	1.77*** (1.33–2.36)
Ethnicity							
Javanese	56.3	31.3 (29.7, 33.0)	45.7 (44.0, 47.5)	15.2 (14.0, 16.5)	7.7 (6.8, 8.6)	22.9 (21.5, 24.4)	1
Sundanese	15.5	22.9 (20.1 25.9)	43.4 (40.0, 46.8)	21.1 (18.4, 24.0)	12. (10.6, 15.1)	33.7 (30.6, 37.0)	1.53*** (1.28–1.83)
Others	28.2	32.7 (30.8, 34.7)	41.5 (39.4, 43.5)	16.5 (15.1, 18.0)	9.3 (8.2, 10.6)	25.8 (24.1, 27.6)	1.04 (0.89–1.22)
Had any health insurance							
No	53.9	32.4 (30.8, 34.1)	46.2 (44.4, 47.9)	14.3 (13.1, 15.5)	7.1 (6.3, 8.1)	21.4 (20.1, 22.9)	1
Yes	46.1	28.1 (26.5, 29.8)	41.8 (40.0, 43.6)	19.0 (17.7, 20.5)	11.0 (9.9, 12.2)	30.0 (28.4, 31.7)	1.22*** (1.23–1.57)
Type of work							
Unemployed	30.6	19.8 (18.1, 21.7)	44.2 (42.0, 46.4)	21.3 (19.6, 23.2)	14.6 (13.2, 16.3)	36.0 (33.9, 38.1)	1
Casual	15.6	36.1 (33.0, 39.4)	45.5 (42.2, 48.7)	13.3 (11.3, 15.7)	5.0 (3.8, 6.6)	18.4 (16.0, 21.0)	0.50*** (0.41–0.62)
Self-employed	39.8	34.6 (32.7, 36.6)	44.4 (42.4, 46.4)	14.5 (13.2, 16.0)	6.4 (5.5, 7.5)	21.0 (19.4, 22.7)	0.57*** (0.49–0.66)
Government/private	14.0	35.2 (32.0, 38.6)	41.9 (38.6, 45.4)	15.0 (12.8, 17.5)	7.8 (6.2, 9.9)	22.8 (20.1, 25.8)	0.50*** (0.40–0.62)
Household expenditure							
Q1 (the lowest)	21.3	33.2 (30.7, 35.9)	49.3 (46.5, 52.1)	12.7 (11.0, 14.6)	4.8 (3.7, 6.1)	17.5 (15.5, 19.6)	1
Q2	20.9	33.5 (30.8, 36.2)	45.0 (42.3, 47.9)	15.6 (13.7, 17.7)	5.8 (4.6, 7.3)	21.5 (19.2, 23.8)	1.28** (1.05–1.58)
Q3	19.8	31.7 (29.1, 34.4)	43.7 (41.0, 46.5)	6.0 (14.0, 18.1)	8.6 (7.2, 10.3)	24.6 (22.2, 17.1)	1.46*** (1.19–1.78)
Q4	19.5	28.8 (26.3, 31.5)	41.5 (38.7, 44.3)	18.8 (16.7, 21.1)	10.9 (9.3, 12.7)	19.7 (27.2, 32.3)	1.80*** (1.47–2.20)
Q5 (the highest)	18.5	24.0 (21.7, 26.5)	40.5 (37.8, 43.3)	19.9 (17.8, 22.2)	15.5 (13.5, 17.6)	35.4 (32.8, 38.1)	2.03*** (1.65–2.50)
Residency							
Rural	48.9	33.3 (31.5, 35.1)	46.4(44.5, 48.3)	14.2 (12.9, 15.5)	6.1 (52.5, 7.0)	20.3 (18.8, 21.8)	1
Urban	51.3	27.7 (26.2, 29.2)	42.0 (40.3, 43.7)	19.0 (17.4, 20.0)	11.6 (10.6, 12.7)	30.3 (28.8, 31.9)	1.37*** (1.19–1.56)
Island							
Java-Bali	78.6	30.3 (28.9, 31.7)	44.7 (43.2, 16.2)	16.0 (15.0, 17.1)	9.0 (8.2, 9.9)	25.1 (23.8, 26.4)	1
Sumatra	14.0	30.6 (28.2, 33.1)	41.1 (38.5, 43.7)	19.1 (17.1, 21.2)	9.2 (7.8, 10.8)	28.3 (26.0, 30.7)	1.34*** (1.14–1.58)
Nusa Tenggara	2.4	37.2 (32.9, 41.7)	47.2 (42.7, 51.7)	13.3 (10.5, 16.6)	2.3 (12.8, 4.1)	15.6 (12.6, 19.1)	0.62*** (0.46–0.83)
Kalimantan	2.4	24.3 (19.7, 29.5)	41.5 (36.1, 47.2)	22.9 (18.6, 27.9)	11.3 (8.2, 15.3)	34.2 (29.1, 39.7)	2.02*** (1.53–2.67)
Sulawesi	2.6	33.6 (28.7, 38.9)	44.7 (39.4, 50.0)	14.2 (10.9, 18.4)	7.5 (5.2, 10.6)	21.7 (17.7, 26.4)	0.87 (0.64–1.18)
Overall Sample	100	30.4 (29.3, 31.6)	44.1 (42.9, 45.4)	16.5 (15.6, 17.4)	8.9 (8.2, 9.6)	25.4 (24.3, 26.5)	

[a] Weighted sample size

[b] We defined multimorbidity if the respondents reported that they had 2 or more chronic conditions related to NCDs. Chronic diseases in IFLS5 included hypertension, diabetes mellitus, asthma, chronic heart diseases, mental health issue, stroke, liver diseases, cancer/malignancies, liver, arthritis, high cholesterol, prostate illness kidney diseases, digestive system diseases.

aOR: adjusted odds ratio

*** p<0.01, ** p<0.05

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Table S6. Robustness check: The effect of multimorbidity on health service use (cross-sectional analysis of 2014 IFLS)

Variables	Health service use			
	Outpatient		Inpatient	
	Any visit	Number of visits	Any visit	Number of visits
	aOR (95% CI)	IRR (95% CI)	aOR (95% CI)	IRR (95% CI)
Number of NCDs (ref. no NCD)				
Single NCD	1.54*** (1.30–1.82)	1.50*** (1.24–1.81)	1.73** (1.17–2.56)	2.03*** (1.36–3.03)
Two NCDs	2.77*** (2.29–3.36)	2.68*** (2.15–3.34)	3.47*** (2.31–5.21)	4.03*** (2.66–6.08)
Three or more NCDs	4.51*** (3.61–5.63)	3.85*** (3.06–4.84)	6.85***(4.45–10.52)	8.78*** (5.73–13.45)
Sex (ref. Male)				
Female	1.26***(1.09–1.45)	1.18**(1.02–1.35)	0.93 (0.72–1.22)	0.81 (0.62–1.07)
Age (ref. 50 – 60 years)				
61 – 70 years	1.01 (0.87–1.18)	0.93 (0.80–1.08)	1.23 (0.91–1.65)	1.23 (0.88–1.72)
71+ years	1.03 (0.85–1.25)	1.01 (0.84–1.21)	1.42 (1.02–2.00)	1.53** (1.01–2.32)
Marital status (ref. Not married)				
Currently married	1.09 (0.93–1.27)	1.04 (0.90–1.21)	1.07 (0.80–1.41)	0.93 (0.70–1.25)
Educational level (ref. No education)				
Primary	0.94 (0.80–1.10)	0.87* (0.74–1.01)	1.02 (0.75–1.39)	0.96 (0.69–1.35)
Junior high school	1.02 (0.80–1.31)	1.07 (0.76–1.52)	0.72 (0.45–1.14)	0.82 (0.47–1.44)
Senior high school	0.87 (0.68–1.10)	0.80* (0.64–1.00)	0.69 (0.44–1.08)	0.63* (0.39–1.00)
Tertiary	0.99 (0.73–1.33)	0.79 (0.55–1.13)	0.58* (0.33–1.02)	0.55* (0.30–1.00)
Ethnicity (ref. Javanese)				
Sundanese	0.93 (0.77–1.13)	0.97 (0.81–1.17)	1.17 (0.84–1.63)	1.21 (0.82–1.79)
Others	1.06 (0.89–1.25)	0.99 (0.84–1.17)	0.78 (0.56–1.08)	0.87 (0.62–1.22)
Insurance coverage (ref. No)				
Yes	1.20*** (1.06–1.37)	1.25*** (1.10–1.44)	2.28*** (1.77–2.95)	2.19*** (1.66–2.89)
Type of work (ref. Unemployed)				
Casual	0.73*** (0.59–0.90)	0.73*** (0.60–0.89)	0.41*** (0.25–0.67)	0.35*** (0.22–0.55)
Self-employed	0.77*** (0.66–0.90)	0.77*** (0.66–0.90)	0.64*** (0.47–0.87)	0.64*** (0.46–0.90)
Government/private	0.70*** (0.56–0.88)	0.75*** (0.60–0.93)	0.43*** (0.28–0.66)	0.53** (0.30–0.94)
Per capita expenditure (ref. Q1)				
Q2	1.36*** (1.10–1.68)	1.40*** (1.14–1.73)	0.86 (0.57–1.31)	0.76 (0.48–1.18)
Q3	1.50*** (1.21–1.85)	1.71*** (1.35–2.17)	1.16 (0.78–1.72)	1.29 (0.80–2.05)
Q4	1.93*** (1.56–2.38)	1.75*** (1.44–2.14)	1.24 (0.83–1.85)	1.35 (0.87–2.08)
Q5	1.87*** (1.50–2.33)	2.02*** (1.63–2.51)	2.06*** (1.38–3.06)	1.98*** (1.32–2.96)
Residency (ref. Rural)				
Urban	0.94 (0.82–1.08)	0.98 (0.86–1.13)	0.93 (0.71–1.21)	1.03 (0.79–1.34)
Region (ref. Java-Bali)				
Sumatra	0.72*** (0.60–0.86)	0.86 (0.72–1.03)	1.32 (0.96–1.82)	1.46** (1.04–2.06)
Nusa Tenggara	0.84 (0.63–1.12)	0.84 (0.63–1.12)	1.83** (1.09–3.06)	1.87** (1.08–3.25)
Kalimantan	0.81 (0.59–1.11)	0.85 (0.62–1.14)	1.46 (0.82–2.58)	1.4 (0.81–2.42)
Sulawesi	0.54*** (0.39–0.75)	0.53*** (0.39–0.71)	1.45 (0.81-2.60)	1.59 (0.85–2.98)

Chronic diseases in IFLS5 included hypertension-diabetes mellitus-asthma-chronic heart diseases-mental health issue-stroke-liver diseases-cancer/malignancies-liver-arthritis-high cholesterol-prostate illness kidney diseases-digestive system diseases.
aOR: adjusted odds ratio, IRR: incidence rate ratio, NCD: non-communicable disease
*** p<0.01, ** p<0.05

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Table S7. Robustness check: The effect of multimorbidity on catastrophic health expenditure (cross-sectional analysis of 2014 IFLS)

Variables	Catastrophic health expenditure		
	10% of total household expenditure	25% of total household expenditure	40% of non-food expenditure
	aOR (95% CI)	aOR (95% CI)	aOR (95% CI)
Number of NCDs (ref. no NCD)			
Single NCD	1.25 (0.94–1.66)	1.18 (0.67–2.09)	1.58 (0.98–2.57)
Two NCDs	2.03*** (1.48–2.79)	2.10** (1.12–3.93)	2.39*** (1.38–4.14)
Three or more NCDs	2.24*** (1.57–3.20)	2.09** (1.06–4.12)	2.17** (1.18–4.01)
Sex (ref. Male)			
Female	0.87 (0.68–1.12)	0.74 (0.43–1.27)	0.90 (0.59–1.37)
Age (ref. 50 – 60 years)			
61 – 70 years	1.24 (0.96–1.60)	1.34 (0.82–2.20)	1.42 (0.94–2.14)
71+ years	1.32 (0.96–1.81)	1.06 (0.53–2.13)	1.48 (0.88–2.51)
Marital status (ref. Not married)			
Currently married	1.44** (1.08–1.91)	1.69* (0.91–3.17)	1.94*** (1.20–3.14)
Educational level (ref. No education)			
Primary	1.14 (0.88–1.48)	1.31 (0.79–2.17)	1.46 (0.98–2.18)
Junior high school	1.11 (0.76–1.63)	1.28 (0.67–2.46)	1.12 (0.63–1.98)
Senior high school	0.73 (0.49–1.08)	0.52 (0.22–1.23)	0.45** (0.21–0.97)
Tertiary	0.74 (0.43–1.27)	0.22 (0.05–1.01)	0.12** (0.02–0.66)
Ethnicity (ref. Javanese)			
Sundanese	0.87 (0.64–1.18)	1.09 (0.62–1.89)	0.83 (0.51–1.35)
Others	0.79 (0.60–1.04)	0.65 (0.36–1.18)	0.47*** (0.28–0.78)
Insurance coverage (ref. No)			
Yes	1 (0.81–1.25)	1.07 (0.71–1.61)	1.02 (0.72–1.44)
Type of work (ref. Unemployed)			
Casual	0.66** (0.46–0.95)	0.56 (0.27–1.16)	0.56 (0.31–1.04)
Self-employed	0.70*** (0.53–0.91)	0.44*** (0.24–0.79)	0.54*** (0.34–0.85)
Government/private	0.57*** (0.39–0.83)	0.41** (0.19–0.88)	0.46** (0.23–0.91)
Per capita expenditure (ref. Q1)			
Q2	0.96 (0.65–1.43)	1.05 (0.47–2.35)	1.24 (0.67–2.33)
Q3	1.42 (0.99–2.02)	1 (0.46–2.17)	1.08 (0.58–2.01)
Q4	1.59** (1.11–2.27)	2.37** (1.15–4.86)	2.18*** (1.21–3.92)
Q5	2.53*** (1.76–3.62)	2.44** (1.18–5.05)	2.75*** (1.51–5.02)
Residency (ref. Rural)			
Urban	1.01 (0.80–1.26)	0.87 (0.56–1.37)	0.94 (0.65–1.35)
Region (ref. Java-Bali)			
Sumatra	0.94 (0.71–1.24)	0.94 (0.55–1.60)	1.36 (0.88–2.09)
Nusa Tenggara	0.81 (0.48–1.37)	1.49 (0.59–3.76)	1.57 (0.68–3.66)
Kalimantan	1.13 (0.69–1.84)	1.5 (0.59–3.83)	1.56 (0.71–3.47)
Sulawesi	1.02 (0.60–1.73)	0.4 (0.08–2.07)	1.18 (0.45–3.10)

Chronic diseases in IFLS5 included hypertension-diabetes mellitus-asthma-chronic heart diseases-mental health issue-stroke-liver diseases-cancer/malignancies-liver-arthritis-high cholesterol-prostate illness kidney diseases-digestive system diseases.
aOR: adjusted odds ratio, IRR: incidence rate ratio, NCD: non-communicable disease
*** p<0.01, ** p<0.05

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Table S8. Robustness check: The effect of multimorbidity on productivity loss (cross-sectional analysis of 2014 IFLS)

Variables	Productivity loss		
	Labour participation	Days primary activity missed	Days stayed in bed
	aOR (95% CI)	IRR (95% CI)	IRR (95% CI)
Number of NCDs (ref. no NCD)			
Single NCD	0.76*** (0.65–0.89)	1.48*** (1.29–1.70)	1.32** (1.01–1.72)
Two NCDs	0.54*** (0.45–0.65)	2.42*** (2.09–2.80)	2.18*** (1.60–2.97)
Three or more NCDs	0.32*** (0.26–0.40)	3.29*** (2.79–3.87)	2.80*** (2.02–3.88)
Sex (ref. Male)			
Female	0.31***(0.27–0.35)	1.05 (0.94–1.18)	1.22 (0.97–1.54)
Age (ref. 50 – 60 years)			
61 – 70 years	0.40*** (0.34–0.46)	0.97 (0.86–1.10)	0.93 (0.72–1.21)
71+ years	0.15*** (0.13–0.18)	1.19** (1.03–1.37)	1.78*** (1.33–2.36)
Marital status (ref. Not married)			
Currently married	1.22*** (1.05–1.41)	1.07 (0.95–1.20)	0.93 (0.72–1.21)
Primary	1.08 (0.92–1.26)	1.02 (0.90–1.17)	1.03 (0.81–1.32)
Junior high school	0.64*** (0.51–0.81)	1.02 (0.85–1.22)	1.01 (0.64–1.61)
Senior high school	0.61*** (0.49–0.76)	0.73*** (0.60–0.89)	0.73 (0.46–1.15)
Tertiary	1.09 (0.79–1.48)	0.59*** (0.43–0.83)	0.37*** (0.19–0.71)
Ethnicity (ref. Javanese)			
Sundanese	0.69*** (0.57–0.83)	1.25*** (1.10–1.43)	1.70*** (1.29–2.24)
Others	0.72*** (0.61–0.86)	0.93 (0.81–1.07)	1.34** (1.01–1.77)
Insurance coverage (ref. No)			
Yes	0.91 (0.80–1.04)	1.02 (0.92–1.13)	0.87 (0.71–1.06)
Type of work (ref. Unemployed)			
Casual		0.51*** (0.43–0.60)	0.28*** (0.20–0.39)
Self-employed	n/a	0.55*** (0.49–0.63)	0.33*** (0.26–0.42)
Government/private		0.44*** (0.37–0.54)	0.22*** (0.14–0.33)
Per capita expenditure (ref. Q1)			
Q2	1.25** (1.03–1.52)	1.02 (0.88–1.19)	1.11 (0.82–1.51)
Q3	1.17 (0.96–1.43)	1.12 (0.95–1.32)	0.8 (0.59–1.09)
Q4	0.96 (0.79–1.17)	0.95 (0.81–1.12)	0.89 (0.66–1.21)
Q5	1.07 (0.86–1.32)	1.02 (0.86–1.20)	0.83 (0.61–1.14)
Residency (ref. Rural)			
Urban	0.57*** (0.50–0.65)	1 (0.90–1.12)	0.88 (0.72–1.09)
Region (ref. Java-Bali)			
Sumatra	1.04 (0.87–1.23)	1.12 (0.97–1.29)	1.03 (0.78–1.36)
Nusa Tenggara	1.17 (0.89–1.54)	1.14 (0.92–1.42)	0.91 (0.59–1.40)
Kalimantan	1.42** (1.02–1.99)	1.16 (0.91–1.48)	0.73 (0.48–1.10)
Sulawesi	0.59*** (0.43–0.79)	1.39** (1.07–1.81)	1.05 (0.70–1.59)

Chronic diseases in IFLS5 included hypertension-diabetes mellitus-asthma-chronic heart diseases-mental health issue-stroke-liver diseases-cancer/malignancies-liver-arthritis-high cholesterol-prostate illness kidney diseases-digestive system diseases.
aOR: adjusted odds ratio, IRR: incidence rate ratio, NCD: non-communicable disease
*** p<0.01, ** p<0.05

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Table S9. Sensitivity analysis: the effect of multimorbidity on health service use

Obesity (BMI ≥25 kg/m2 as obese) is included in the clustering of multimorbidity

Variables	Health service use							
	Outpatient				Inpatient			
	Any visit[a)]		Number of visits[b)]		Any visit[a)]		Number of visits[b)]	
	aOR (95% CI)	p values	IRR (95% CI)	p values	aOR (95% CI)	p values	IRR (95% CI)	p values
Number of NCDs (ref. no NCD)								
Single NCD	1.18 (0.98–1.43)	0.086	1.24 (1.04–1.50)	0.020	1.16 (0.79–1.70)	0.451	1.16 (0.79–1.70)	0.488
Two NCDs	1.82 (1.47–2.25)	0.000	1.83 (1.50–2.25)	0.000	1.78 (1.18–2.69)	0.006	1.78 (1.18–2.69)	0.002
Three or more NCDs	3.27 (2.55–4.19)	0.000	2.85 (2.26–3.60)	0.000	2.73 (1.76–4.25)	0.000	2.73 (1.76–4.25)	0.000
Period (ref.2007)								
2014	1.33 (1.15–1.53)	0.000	1.29 (1.12–1.49)	0.000	1.72 (1.29–2.29)	0.000	1.72 (1.29–2.29)	0.000
Sex (ref. Male)								
Female	1.19 (1.00–1.41)	0.049	1.13 (0.96–1.33)	0.139	0.91 (0.67–1.24)	0.537	0.91 (0.67–1.24)	0.413
Age (ref. 50 – 60 years)								
61 – 70 years	1.06 (0.90–1.26)	0.475	1.05 (0.89–1.23)	0.588	1.09 (0.79–1.50)	0.603	1.09 (0.79–1.50)	0.332
71+ years	1.20 (0.96–1.50)	0.109	1.15 (0.93–1.41)	0.187	1.58 (1.07–2.33)	0.020	1.58 (1.07–2.33)	0.020
Marital status (ref. Not married)								
Currently married	1.09 (0.92–1.31)	0.323	1.15 (0.97–1.36)	0.105	1.05 (0.77–1.44)	0.742	1.05 (0.77–1.44)	0.962
Educational level (ref. No education)								
Primary	1.06 (0.88–1.27)	0.556	0.97 (0.82–1.16)	0.760	1.09 (0.78–1.51)	0.630	1.09 (0.78–1.51)	0.796
Junior high school	1.04 (0.78–1.40)	0.777	1.11 (0.85–1.46)	0.441	1.18 (0.73–1.92)	0.498	1.18 (0.73–1.92)	0.105
Senior high school	1.01 (0.76–1.35)	0.954	0.94 (0.72–1.23)	0.636	0.78 (0.47–1.29)	0.335	0.78 (0.47–1.29)	0.147
Tertiary	1.18 (0.79–1.76)	0.427	0.84 (0.57–1.23)	0.371	0.94 (0.50–1.78)	0.858	0.94 (0.50–1.78)	0.495
Ethnicity (ref. Javanese)								
Sundanese	0.91 (0.72–1.16)	0.456	0.92 (0.74–1.15)	0.486	0.90 (0.59–1.37)	0.628	0.90 (0.59–1.37)	0.944
Others	1.02 (0.85–1.24)	0.802	0.92 (0.77–1.09)	0.313	0.91 (0.65–1.28)	0.603	0.91 (0.65–1.28)	0.557
Insurance coverage (ref. No)								
Yes	1.48 (1.27–1.73)	0.000	1.57 (1.36–1.81)	0.000	2.02 (1.52–2.69)	0.000	2.02 (1.52–2.69)	0.000
Type of work (ref. Unemployed)								
Casual	0.77 (0.61–0.97)	0.025	0.66 (0.53–0.82)	0.000	0.48 (0.30–0.79)	0.003	0.48 (0.30–0.79)	0.001
Self-employed	0.83 (0.70–0.99)	0.041	0.76 (0.64–0.89)	0.001	0.60 (0.43–0.83)	0.002	0.60 (0.43–0.83)	0.001
Government/private	0.74 (0.56–0.98)	0.034	0.67 (0.52–0.88)	0.004	0.61 (0.36–1.02)	0.061	0.61 (0.36–1.02)	0.242
Per capita household expenditure (ref. Q1)								
Q2	1.48 (1.17–1.86)	0.001	1.50 (1.20–1.87)	0.000	1.26 (0.80–2.01)	0.322	1.26 (0.80–2.01)	0.500
Q3	1.71 (1.35–2.15)	0.000	1.74 (1.39–2.17)	0.000	1.77 (1.14–2.76)	0.012	1.77 (1.14–2.76)	0.003
Q4	1.70 (1.34–2.16)	0.000	1.77 (1.41–2.22)	0.000	1.44 (0.90–2.31)	0.131	1.44 (0.90–2.31)	0.092
Q5	1.79 (1.39–2.31)	0.000	1.98 (1.56–2.51)	0.000	2.67 (1.68–4.26)	0.000	2.67 (1.68–4.26)	0.000
Residency (ref. Rural)								
Urban	0.87 (0.74–1.02)	0.093	0.92 (0.79–1.07)	0.258	0.96 (0.72–1.28)	0.775	0.96 (0.72–1.28)	0.689
Region (ref. Java-Bali)								
Sumatra	0.83 (0.67–1.03)	0.094	1.03 (0.85–1.26)	0.736	1.21 (0.84–1.75)	0.294	1.21 (0.84–1.75)	0.322
Nusa Tenggara	0.69 (0.48–0.99)	0.043	0.62 (0.44–0.87)	0.006	1.24 (0.69–2.22)	0.467	1.24 (0.69–2.22)	0.707
Kalimantan	1.04 (0.71–1.50)	0.851	1.31 (0.94–1.83)	0.115	0.99 (0.50–1.97)	0.982	0.99 (0.50–1.97)	0.764
Sulawesi	0.72 (0.48–1.07)	0.107	0.68 (0.47–0.99)	0.043	0.52 (0.22–1.22)	0.134	0.52 (0.22–1.22)	0.055

[a)] Multilevel logistic regression model

[b)] Multilevel negative binomial regression model

Obesity (BMI ≥25 kg/m2 as obese) is included in the clustering of multimorbidity

aOR: adjusted odds ratio, IRR: Incidence rate ratio, NCD: non-communicable disease

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Table S10. Sensitivity analysis: the effect of multimorbidity on catastrophic expenditure

Obesity (BMI ≥25 kg/m2 as obese) is included in the clustering of multimorbidity

Variables	Catastrophic health expenditure					
	10% of total household expenditure[a)]		25% of total household expenditure[a)]		40% of non-food expenditur [a)]	
	aOR (95% CI)	p values	aOR (95% CI)	p values	aOR (95% CI)	p values
Number of NCDs (ref. no NCD)						
Single NCD	1.12 (0.84–1.51)	0.434	0.89 (0.54–1.47)	0.642	0.93 (0.62–1.41)	0.743
Two NCDs	1.23 (0.88–1.72)	0.235	1.27 (0.74–2.17)	0.382	1.22 (0.77–1.91)	0.396
Three or more NCDs	1.66 (1.12–2.45)	0.011	0.99 (0.50–1.94)	0.976	1.08 (0.63–1.88)	0.773
Period (ref.2007)						
2014	1.37 (1.09–1.74)	0.008	1.21 (0.81–1.81)	0.351	1.16 (0.84–1.62)	0.367
Sex (ref. Male)						
Female	0.92 (0.72–1.19)	0.528	1.00 (0.64–1.54)	0.991	1.01 (0.70–1.45)	0.949
Age (ref. 50 – 60 years)						
61 – 70 years	1.18 (0.91–1.53)	0.207	1.47 (0.95–2.29)	0.085	1.49 (1.03–2.16)	0.033
71+ years	1.08 (0.77–1.53)	0.651	0.87 (0.45–1.67)	0.672	1.37 (0.83–2.25)	0.218
Marital status (ref. Not married)						
Currently married	1.54 (1.15–2.05)	0.003	1.66 (1.01–2.71)	0.044	1.82 (1.21–2.72)	0.004
Educational level (ref. No education)						
Primary	0.93 (0.70–1.23)	0.607	0.87 (0.53–1.44)	0.596	0.88 (0.59–1.31)	0.530
Junior high school	0.88 (0.57–1.35)	0.555	1.04 (0.51–2.09)	0.921	0.67 (0.35–1.28)	0.227
Senior high school	0.85 (0.55–1.29)	0.442	1.05 (0.53–2.07)	0.885	0.82 (0.45–1.47)	0.500
Tertiary	0.39 (0.18–0.84)	0.016	0.13 (0.02–0.96)	0.045	0.18 (0.04–0.75)	0.018
Ethnicity (ref. Javanese)						
Sundanese	0.83 (0.57–1.21)	0.339	1.64 (0.91–2.95)	0.099	1.17 (0.71–1.94)	0.529
Others	0.75 (0.56–1.02)	0.069	0.96 (0.57–1.60)	0.872	0.72 (0.47–1.10)	0.129
Insurance coverage (ref. No)						
Yes	0.94 (0.74–1.20)	0.613	0.83 (0.54–1.27)	0.388	0.80 (0.56–1.15)	0.227
Type of work (ref. Unemployed)						
Casual	0.62 (0.42–0.91)	0.016	0.59 (0.31–1.14)	0.116	0.56 (0.33–0.95)	0.032
Self-employed	0.64 (0.47–0.87)	0.005	0.65 (0.41–1.03)	0.068	0.66 (0.45–0.97)	0.033
Government/private	0.61 (0.38–0.97)	0.038	0.77 (0.37–1.61)	0.488	0.63 (0.33–1.22)	0.169
Per capita household expenditure (ref. Q1)						
Q2	1.11 (0.74–1.65)	0.619	1.40 (0.66–2.94)	0.379	1.54 (0.85–2.77)	0.151
Q3	1.46 (0.99–2.15)	0.058	1.74 (0.85–3.58)	0.130	1.67 (0.93–2.99)	0.086
Q4	2.01 (1.34–3.01)	0.001	2.58 (1.27–5.26)	0.009	2.42 (1.36–4.31)	0.003
Q5	3.27 (2.10–5.11)	0.000	4.64 (2.29–9.38)	0.000	4.71 (2.66–8.34)	0.000
Residency (ref. Rural)						
Urban	0.99 (0.74–1.31)	0.936	0.85 (0.52–1.40)	0.526	0.88 (0.59–1.32)	0.550
Region (ref. Java-Bali)						
Sumatra	0.82 (0.58–1.16)	0.257	0.78 (0.43–1.41)	0.411	1.12 (0.70–1.78)	0.633
Nusa Tenggara	0.70 (0.37–1.35)	0.287	1.22 (0.39–3.77)	0.730	0.87 (0.33–2.29)	0.772
Kalimantan	0.86 (0.46–1.59)	0.632	0.77 (0.26–2.30)	0.637	0.96 (0.40–2.26)	0.918
Sulawesi	0.83 (0.43–1.61)	0.584	1.00 (0.36–2.79)	0.994	1.08 (0.44–2.63)	0.864

[a)] Multilevel logistic regression model

Obesity (BMI ≥25 kg/m2 as obese) is included in the clustering of multimorbidity

aOR: adjusted odds ratio, NCD: non-communicable disease

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Table S11. Sensitivity analysis: the effect of multimorbidity on productivity loss

Obesity (BMI ≥25 kg/m2 as obese) is included in the clustering of multimorbidity

Variables	Productivity loss					
	Labour participation[a)]		Days primary activity missed[b)]		Days stayed in bed[b)]	
	aOR (95% CI)	p values	IRR (95% CI)	p values	IRR (95% CI)	p values
Number of NCDs (ref. no NCD)						
Single NCD	0.66 (0.54–0.82)	0.000	1.16 (0.99–1.36)	0.063	1.10 (0.82–1.48)	0.533
Two NCDs	0.45 (0.35–0.58)	0.000	1.70 (1.41–2.04)	0.000	1.37 (0.98–1.92)	0.065
Three or more NCDs	0.37 (0.27–0.49)	0.000	2.21 (1.76–2.76)	0.000	2.16 (1.44–3.25)	0.000
Period (ref. 2007)						
2014	0.76 (0.65–0.89)	0.001	1.54 (1.35–1.75)	0.000	1.44 (1.13–1.85)	0.004
Sex (ref. Male)						
Female	0.22 (0.17–0.27)	0.000	0.96 (0.83–1.11)	0.555	0.90 (0.68–1.20)	0.480
Age (ref. 50 – 60 years)						
61 – 70 years	0.36 (0.29–0.44)	0.000	1.02 (0.89–1.18)	0.758	1.15 (0.87–1.52)	0.336
71+ years	0.10 (0.08–0.13)	0.000	1.17 (0.97–1.41)	0.094	1.77 (1.24–2.52)	0.002
Marital status (ref. Not married)						
Currently married	1.49 (1.22–1.82)	<0.0001	1.18 (1.01–1.37)	0.032	0.96 (0.72–1.29)	0.809
Educational level (ref. No education)						
Primary	0.90 (0.72–1.13)	0.372	0.92 (0.79–1.07)	0.269	1.03 (0.77–1.38)	0.851
Junior high school	0.41 (0.29–0.58)	<0.0001	0.91 (0.71–1.16)	0.438	0.68 (0.42–1.10)	0.118
Senior high school	0.43 (0.30–0.61)	<0.0001	0.64 (0.50–0.83)	0.001	0.65 (0.40–1.04)	0.073
Tertiary	0.56 (0.34–0.92)	0.021	0.52 (0.36–0.75)	<0.0001	0.42 (0.20–0.88)	0.022
Ethnicity (ref. Javanese)						
Sundanese	0.48 (0.36–0.65)	<0.0001	1.39 (1.14–1.70)	0.001	1.51 (1.03–2.21)	0.035
Others	0.80 (0.63–1.01)	0.059	1.13 (0.97–1.33)	0.123	1.13 (0.84–1.53)	0.425
Insurance coverage (ref. No)						
Yes	0.82 (0.69–0.98)	0.032	1.13 (0.99–1.29)	0.077	1.13 (0.88–1.46)	0.329
Type of work (ref. Unemployed)						
Casual	N/A	N/A	0.69 (0.57–0.84)	<0.0001	0.41 (0.28–0.60)	<0.0001
Self-employed	N/A	N/A	0.68 (0.58–0.79)	<0.0001	0.51 (0.38–0.69)	<0.0001
Government/private	N/A	N/A	0.60 (0.47–0.76)	<0.0001	0.56 (0.35–0.90)	0.017
Per capita household expenditure (ref. Q1)						
Q2	1.36 (1.06–1.75)	0.016	1.03 (0.85–1.24)	0.769	0.97 (0.68–1.38)	0.848
Q3	1.27 (0.98–1.64)	0.071	1.17 (0.97–1.42)	0.095	1.11 (0.78–1.59)	0.557
Q4	1.13 (0.86–1.47)	0.383	1.05 (0.86–1.29)	0.602	0.99 (0.68–1.43)	0.944
Q5	1.35 (1.01–1.80)	0.043	1.26 (1.02–1.55)	0.032	0.89 (0.60–1.33)	0.577
Residency (ref. Rural)						
Urban	0.42 (0.34–0.52)	<0.0001	0.92 (0.80–1.06)	0.239	0.69 (0.52–0.90)	0.006
Region (ref. Java-Bali)						
Sumatra	0.91 (0.70–1.20)	0.519	1.14 (0.95–1.38)	0.162	1.10 (0.78–1.55)	0.573
Nusa Tenggara	0.68 (0.44–1.04)	0.077	0.86 (0.64–1.15)	0.309	1.15 (0.66–2.00)	0.629
Kalimantan	1.22 (0.75–1.99)	0.418	0.86 (0.63–1.17)	0.329	0.92 (0.51–1.67)	0.794
Sulawesi	0.34 (0.21–0.55)	<0.0001	1.05 (0.76–1.46)	0.754	1.07 (0.58–1.98)	0.826

[a)] Multilevel logistic regression model

[b)] Multilevel negative binomial regression model

aOR: adjusted odds ratio, IRR: incidence rate ratio, NCD: non-communicable disease

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Table S1. STROBE Statement

	Item	Recommendation	Reported on page	Relevant text from manuscript
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	2	"Panel Data Analysis"
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	3	"Multimorbidity is associated with substantial direct and indirect costs to individuals, households, and the wider society."
Introduction				
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4, 5	"Evidence from high-income countries (HICs) has found that…"
Objectives	3	State specific objectives, including any prespecified hypotheses	5,6	"to examine multimorbidity levels, and their relation to households' socioeconomic characteristics, health service use, catastrophic health expenditures, and productivity loss."
Methods				
Study design	4	Present key elements of study design early in the paper	6	"The study used panel data from two waves of the Indonesian Family Life Survey (IFLS)."
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	6	"Waves 5 was conducted between September 2014–March 2015."
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	6	"We included respondents aged 50 years and above in 2014, excluded those who did not participate in both Waves 4 and 5, and those with missing values for the study variable."
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case		N/A
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	7–9	In "variables" subsection.
Data sources/	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of	7–9	In "variables" subsection. Details of the

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	Item	Recommendation	Reported on page	Relevant text from manuscript
measurement		assessment methods if there is more than one group		measurements are available in Table S2
Bias	9	Describe any efforts to address potential sources of bias	10	"Taking into account the hierarchical (nested) nature of the dataset (i.e. observations nested within individuals, and individuals nested within households, and districts), a multilevel level model approach was used."
Study size	10	Explain how the study size was arrived at	10	Our final sample is 3,678 respondents (the sample flowchart is presented in Figure S1).
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	7	In "variables" subsection, i.e. "A total of 10 NCDs were used to quantify the number of NCDs (0, 1, 2, 3 or more) and respondents with two or more NCDs were categorized as having multimorbidity (categorized as 0 or 1)"
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	10	In "statistical analysis" subsection. For example "…, adjusting for covariates"
		(*b*) Describe any methods used to examine subgroups and interactions	10	"We described the patterns of multimorbidity across different population subgroups…"
		(*c*) Explain how missing data were addressed	7	"…excluded those who did not participate in both Waves 4 and 5, and those with missing values for the study"
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy	7	"…excluded those who did not participate in both Waves 4 and 5, and those with missing values for the study"
		(*e*) Describe any sensitivity analyses	10	"We conducted two robustness analyses."
Results				
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	32	Figure S1: Sampling flow chart

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	Item	Recommendation	Reported on page	Relevant text from manuscript
		(b) Give reasons for non-participation at each stage	32	Figure S1: Sampling flow chart
		(c) Consider use of a flow diagram	32	Figure S1: Sampling flow chart
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	32	Figure S1: Sampling flow chart
		(b) Indicate number of participants with missing data for each variable of interest	32	Figure S1: Sampling flow chart
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	32	Figure S1: Sampling flow chart
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	26	Table 1 and Table 2
		Case-control study—Report numbers in each exposure category, or summary measures of exposure		N/A
		Cross-sectional study—Report numbers of outcome events or summary measures		
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	27–30	Table 2 – Table 5. For example, "Respondents with a single NCD were 1·61 times more likely (95% CI 1·21-2·14) to have experienced an outpatient visit in the past four weeks compared to those without an NCD."
		(*b*) Report category boundaries when continuous variables were categorized	37–38	Table S2: List of variables for 2007 and 2014 IFLS analyses
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period		N/A
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	42–47	Tables S6–11. For example, "Our robustness analysis using cross-sectional analysis using 2014 cross-sectional dataset that consists of 14 physical NCDs (Tables S6–8) showed consistent results"
Discussion				

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	Item	Recommendation	Reported on page	Relevant text from manuscript
Key results	18	Summarise key results with reference to study objectives	16	"Multimorbidity was associated with higher use of healthcare services, higher probability of catastrophic health expenditure, and a reduction in productivity."
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	18–19	"There are several limitations to our study."
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	18–19	"Our findings should be interpreted with causation since the assessment of chronic diseases was mostly based on self-reporting and may cause under- or over-reporting of the prevalence"
Generalisability	21	Discuss the generalisability (external validity) of the study results	19	"This research intentionally focused on the older population due to a significantly higher burden of NCDs in this population group."
Other information				
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	20	Funding "This research received no specific grant from any funding agency in the public, commercial or not-for-profit sectors"

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Impact of noncommunicable disease multimorbidity on health service use, catastrophic health expenditure, and productivity loss in Indonesia: a population-based panel data analysis study

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Impact of noncommunicable disease multimorbidity on health service use, catastrophic health expenditure, and productivity loss in Indonesia: a population-based panel data analysis study

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Abstract

Objectives

To examine noncommunicable diseases (NCDs) multimorbidity levels, and their relation to households' socioeconomic characteristics, health service use, catastrophic health expenditures, and productivity loss.

Method

We utilised a panel dataset from two waves of the Indonesian Family Life Survey (IFLS) conducted in 2007 and 2014. IFLS is an ongoing longitudinal survey that is representative of 83% of the total population in Indonesia. We included respondents aged 50 years old and above in 2007 who participated in both waves. The total number of participants in this study are 3,678 respondents. Our main outcomes are health service use (outpatient and inpatient care), financial burden (catastrophic health expenditure), and productivity loss (labour participation, days primary activity missed, days stayed in bed). We applied multilevel logistic regression and negative binomial regression models to assess the associations between NCD multimorbidity and the binary outcome variables and count variables, respectively.

Results

Women were more likely to have NCD multimorbidity than men and the prevalence of multimorbidity increased with higher socioeconomic status. NCD multimorbidity was associated with a substantially higher number of outpatient visits (compared with those without NCDs, incidence rate ratio [IRR] 4.30, 95% CI 3.37–5.47 for individuals with three or more NCDs), a higher number of hospital visits (IRR 5.76, 95% CI 3.11–10.66 for individuals with three or more NCDs). NCD multimorbidity was also associated

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with a greater likelihood of experiencing catastrophic health expenditure (for three or more NCDs, adjusted odds ratio [aOR] 1.69, 95% CI 1.02–2.81) and lower participation in the labour force (aOR 0.18, 95% CI 0.10–0.34) compared to those without NCDs.

Conclusions

NCD multimorbidity is associated with substantial direct and indirect costs to individuals, households, and the wider society. Our study highlights the importance of preparing health systems for addressing the burden of multimorbidity in LMICs.

Keywords Multimorbidity, Indonesia, noncommunicable diseases, health service use, catastrophic health expenditure, productivity loss.

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Strengths and limitations of this study

- To our knowledge, our study provides the first comprehensive analysis using the single largest longitudinal survey in Indonesia, which examined the impact of multimorbidity on health service use, catastrophic health expenditure, and productivity loss.
- This study applied multilevel mixed-effects regression models to examine factors associated with multimorbidity and its relationship to the outcome variables, while taking into account the hierarchical (nested) nature of the dataset.
- Our findings should be interpreted with caution since the assessment of NCDs was mostly based on self-reporting, which may not capture the true prevalence rate .
- Despite the fifth waves of IFLS dataset was conducted between 2014 and 2015, the longitudinal design of the survey is extremely useful for measuring the impact of chronic diseases, accounting for within-individual variations over-time.

Introduction

Noncommunicable diseases (NCDs) continues to be the leading cause of global burden of diseases, with 78% of NCD-related mortality concentrated in low-income and middle-income countries (LMICs).[1] The current COVID-19 pandemic highlights that the presence of NCDs can increase the fatality risk of a communicable disease.[2] In Indonesia, the third most populous country among LMICs (after China and India) with a population of 273 million, has seen rapid demographic and epidemiological transitions over the last few decades. The threat of NCDs is expected to rise with the aging population (population aged 65 or above), which is projected to account for a quarter of the population by 2070.[3] Concurrently, the prevalence of NCD multimorbidity, defined as the presence of two or more NCDs, is expected to rise rapidly in many LMICs, as both life expectancy and exposure to risk factors increase.[4] Indonesia has started recognising the burden of NCDs due to its substantial contribution to the top causes of death and disability-adjusted life years (DALYs).[5] However, current Indonesia health programs remain limited to curative services, focusing on single

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chronic disease as opposed to assessing and mitigating the impact of multimorbidity on the individual, health system and wider society.

COVID-19 pandemic emphasises the importance of health systems responsiveness to multimorbidity. Historically, the growing burden of multimorbidity in LMICs were highlighted in the United Nations High-Level Meetings on NCDs in 2011, 2014, and 2018.[6] LMICs typically have low levels of government expenditure for health and inadequate health insurance coverage, which often results in higher levels of out-of-pocket expenditure (OOPE) and risk of impoverishing patients with chronic health conditions.[7,8] The economic burden of multimorbidity is further compounded by the fact that multiple healthcare specialists typically manage multimorbid patients in LMICs.[9] This leads to inefficiencies with numerous different hospital visits, polypharmacy, and suboptimal disease management.[9,10]

While the Indonesian health system is mainly funded by the government, it only spends around 2% of its GDP on health, which is significantly lower than other LMICs with comparable income level.[11] Approximately half of all health spending is covered by the public sector and one-third comes from OOP payment.[12] While the primary health care (PHC) centres are designed as gatekeepers for primary prevention for NCDs, studies have found limited capacity of PHC in proper management of NCDs.[13–15] There is also high public funding allocations to curative services at the hospital-level,[16] with limited investment in preventive and promotive health services.[12] Further, the poor and those living in limited-resource regions have generally lower hospital utilisation due to geographical barriers and high transportation costs.[17,18] Low overall government health

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spending, coupled with limited investment in PHC and the high burden of NCDs may further increase the high OOPE in Indonesia and inequitable access to care.[5]

The Indonesian national health insurance program expansion in 2014 was designed to achieve universal coverage by 2019.[19] However, as of August 2020, the insurance coverage was only at 85.5%,[20] leaving around 40 million people remain uncovered. Furthermore, the program has been in funding deficit since its inception and recent studies identified that the insurance program may not be financially sustainable.[1,2] Further, NCDs were responsible for around 60% of total spending of the insurance program. Therefore, addressing NCDs through preventive and promotive programs is pertinent to strengthen the Indonesian health system and the sustainability of its health insurance program.

Evidence from high-income countries (HICs) has found that apart from the negative impact on health outcomes, multimorbidity imposes substantial economic costs on individuals and households. This is because patients with multimorbidity incur large medical expenditures and are more likely to be absent from work.[8,21,22] However, there is no previous study in Indonesia that has examined the economic burden of NCD multimorbidity, as earlier studies have focused on the burden of a single NCD.[23] Results from this study may inform health systems reform across the region and be applicable to similar LMICs. We present the first study that uses longitudinal data to examine NCD multimorbidity levels, and their relationship to households' socioeconomic characteristics, health service use, catastrophic health expenditures, and productivity loss.

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Methods

Sample and data

We utilised panel data from two waves of the Indonesian Family Life Survey (IFLS) conducted in 2007 (Wave 4) and 2014 (Wave 5). IFLS is an ongoing longitudinal survey that started in 1993 with four subsequent rounds of data collection (1997/1998, 2000, 2007/2008, and 2014). The original sample was based on 13 out of 27 provinces in 1993, representing 83% of the population. Wave 5 was conducted between September 2014–March 2015, with 76% re-contact rate from the main respondents of Wave 1. The dataset contains information at the individual- and household-level , including sociodemographic characteristics, healthcare utilisation and expenditure, and labour participation. The objectives and methods of the IFLS are detailed elsewhere.[24,25] This study included respondents aged 50 years and above in 2007 who participated in both Waves 4 and 5, and excluded those with missing values for the study variable. Our final sample is 3,678 respondents and a sample flowchart is presented in Figure S1.

Variables

Multimorbidity

Our main variable of interest was multimorbidity. Fourteen types of NCDs were included in Wave 5, but only 10 NCDs in Wave 4. For consistency, our main analysis used 10 NCDs that were available in both waves, as the following: hypertension, diabetes, asthma, heart attack/coronary heart diseases, liver disease, stroke, cancer, arthritis/rheumatism, hypercholesterolemia, and depression/mental illness. The four NCDs that were only included in Wave 5 were: prostate diseases, kidney diseases (excluding malignancy), digestive diseases, and memory-related diseases.

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NCD status was either identified through self-reporting or physical examination. In the self-report section, respondents who answered affirmatively to the question, "Has a doctor/paramedic/nurse/midwife ever told you that you had any of these conditions?", were defined as reporting an NCD. For hypertension and hypercholesterolemia, the diagnoses were confirmed through a physical examination conducted by trained nurses, i.e. blood pressure and total cholesterol levels. All IFLS respondents aged 15 years and older had their blood pressure recorded three times on alternate arms using Omron self-inflating sphygmomanometers by trained nurses.[24,25] In our analysis, a respondent was categorised as having hypertension if the mean measurement of systolic blood pressure was 140 mm Hg and/or mean diastolic blood pressure was 90 mm Hg or the respondent self-reported having been diagnosed with hypertension.[26] We also included hypercholesterolemia, defined as total blood cholesterol value 240 mg/dl, as morbidity.[27] It is important to note that different measurements of hypercholesterolemia were used in Wave 4 and 5. Blood test for total cholesterol was performed in Wave 4 as opposed to self-reporting of hypercholesterolemia in Wave 5.

A total of 10 NCDs were used to quantify the number of NCDs (0, 1, 2, 3 or more) and respondents with two or more NCDs were categorised as having multimorbidity (0 or 1). Previous studies have typically considered hypertension, obesity, and hypercholesterolemia as risk factors of NCDs and their inclusion in the multimorbidity clustering remains inconsistent.[23,28] Therefore, in the sensitivity analysis, we included obesity, defined as having BMI $\geq$25 kg/m^2, in the clustering of multimorbidity.[29] All statistical analyses were conducted using STATA 13.0.

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Outcome variables

The three main outcomes are: health service use and financial burden as the direct cost and productivity loss as the indirect cost of multimorbidity. Respondents were asked about the number of outpatient visits (in the last four weeks) and inpatient visits (in the last 12 months) and OOPE. The data on OOPE was also collected with four weeks and 12 months recall period for outpatient and inpatient visits, respectively. We calculated the total annual OOPE by multiplying OOPE for outpatient visits with 13 (as the reference period of outpatient expenditure in the IFLS is four weeks and a year consists of 52 weeks), and added OOPE for inpatient visits. The total OOPE reflects all costs associated with outpatient or inpatient visits, including medication, medical consultation, and laboratory tests.

Catastrophic health expenditure occurs when OOPE exceed certain thresholds of a household's expenditure. The thresholds used in this study were 10% and 25% of total household expenditure (as proposed by the Sustainable Development Goal 3 targets), and the WHO's recommendation at 40% of household's capacity to pay. Capacity to pay is defined as the household's ability to pay for other expenses, including medical costs, after having household subsistence needs met.[30] Household subsistence needs are proxied by the household non-food expenditure variable. Catastrophic health expenditure () occurrence is expressed as follows:

$$cata_h = 1 \; if \; \frac{HS_h}{THE_h} or \; \frac{HS_h}{CTP_h} > z, \text{ and otherwise is zero.}$$

Where $HS_h$is the total OOPE for health, THE_h is the total household expenditure, CTP_h is capacity to pay, and z is the threshold of capacity to pay. In using the proportion of total OOPE for health to total household expenditure (THE), the threshold z was set at 10% and 25%. Further, in using the proportion of OOPE for health to capacity to pay

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(CTP), the threshold *z* was set at 40%. All monetary values were adjusted for inflation and converted to 2014 International Dollars.[31]

Productivity loss was assessed based on: (1) labour participation; (2) the number of days of primary activity missed due to poor health; and (3) number of days confined to bed. Labour participation status was defined as the respondent's employment status at the time of the survey. The number of days of primary daily activity missed and days confined to bed were included in the health conditions section of the survey, with a four week recall period.

Covariates

Sociodemographic factors included were: sex, age groups (50-60, 61-70, above 70 years), marital status (currently and not currently married), education (no education, primary, junior high school, senior high school, tertiary), ethnicity (Javanese, Sundanese, others), coverage of health insurance (no, yes), type of work (unemployed, casual, self-employed, government/private), and respondents' economic status (per capita expenditure for consumption). The economic status was categorised into quintiles: q1 (lowest) to q5 (highest). We also included residency (rural, urban), region of residency (Java-Bali, Sumatra, Nusa Tenggara, Kalimantan, Sulawesi), and period (using wave 2007 as the reference group) as covariates. Detailed definitions and categorisations are available in Table S1. It should be noted that IFLS did not include the eastern regions, Papua and West Papua, which are considered to be underdeveloped.

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Statistical analysis

We described the patterns of multimorbidity across different population subgroups and presented the weighted percentages with 95% confidence interval (CI). Taking into account the hierarchical (nested) nature of the dataset (i.e. observations nested within individuals, and individuals nested within households, and districts),[32] a multilevel level model approach was used to examine factors associated with multimorbidity and its relation to the outcome variables. Multilevel negative binomial regression models were performed to examine the association between multimorbidity and the numbers of outpatient visits and days in the hospital. We used negative binomial models instead of Poisson models due to the over-dispersion of the count data variable. We applied multilevel logistic regression models to observe binary outcome variables and calculated the intra-class correlation coefficients (ICC). The multilevel analyses were conducted using unweighted data, since rather than deriving nationally representative estimates, our aim was on testing the association between multimorbidity and the outcomes and examine the mixed effects.[33] We conducted a robustness check to investigate the association between multimorbidity and costs using the 2014 cross-sectional dataset, that contains information for four additional NCDs than the 2007 Wave.

Patient and public involvement

Neither patients nor the public were involved in this secondary data analysis.

Results

Descriptive statistics

Table 1 and Table S2 presents the respondents' characteristics by multimorbidity status in 2007 and 2014. The median age in 2007 was 58 years (IQR 54–65), 53.9% were

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female, 74.4% were married, 16.5% had at least secondary education level or above and only 25.5% had health insurance coverage. In 2014, the median age was 65 years (IQR 60–72), and health insurance coverage increased to 42.8%.

A similar prevalence of NCD multimorbidity was observed between 2007 (21.0%, 95% CI 19.6-22.6) and 2014 (22.0%, 95% CI 20.6–23.6). The prevalence of multimorbidity increased with rising socioeconomic status. For example, in 2014, the prevalence increased from 18.0% (95% CI 16.9–20.7) to 41.2% (95% CI 31.6–51.6) between respondents with no education and those with tertiary education. Similarly, the prevalence increased from 13.5% (95% CI 11.1–16.2) to 36.2% (95% CI 32.2–40.5) between the lowest and highest wealth quintiles. The trend of increasing multimorbidity was observed for all age groups, shown in Figure 1, where the fifth and fourth wealth quintiles had a higher prevalence of NCD multimorbidity than the lower quintiles. The prevalence of multimorbidity by level of education is available in Figure S2.

The regression results show that NCD multimorbidity was more likely among those with higher socioeconomic status (Table 1). Respondents in the highest wealth quintile were more likely to report NCD multimorbidity, compared with those in the lowest quintile (aOR 2.22, 95% CI 1.72–2.86). Compared with those with lower educational attainment, respondents with higher educational attainment were more likely to experience NCD multimorbidity (aOR 1.54, 95% CI 1.01–2.34 for tertiary level completed). Additionally, the prevalence of multimorbidity was higher in females than males (aOR 1.74, 95% CI 1.46–2.08) and those living in urban areas (aOR 1.41, 95% CI 1.19–1.67). The ICC shows that above 53% (1-[0.34+0.13]) of the variance can be ascribed to between-individual level differences (Table S3).

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Multimorbidity and health service use

The probability of using outpatient and inpatient care and the number of visits increased with more NCD diagnoses (Table 2, Table 3). Respondents with a single NCD were 1.35 times more likely (95% CI 1.15–1.58) to have experienced an outpatient visit in the past four weeks compared to those without an NCD. The odds of an outpatient visit increased to 4.66 times (95% CI 3.55–6.11), while the incidence rate increased by 4.25 times (95% CI 3.33–5.42) in those with three or more NCDs. Furthermore, the incidence of inpatient visits was 3.68 times (95% CI 2.21–6.12) higher in those with three or more NCDs, compared to those without an NCD.

We reported the results of ICC in Table S3. We found that 14% and 11% of the variance in the outpatient visit were attributable to the differences within-individuals and households, respectively. Between-individual variation accounted for the largest variation, where it explained 75% (1-[0.14+0.11]) and 65% (1-[0.25+0.12]) of outpatient and inpatient visit, respectively. No influence of district–level variables was found (ICC=0).

Multimorbidity and financial burden

The mean OOPE for outpatient care incurred by respondents during the last four weeks increased from INT$17 in those without any NCDs to INT$60 in those with three or more NCDs in 2014 (Table 2). Similarly, for inpatient visits, having three or more NCDs resulted in a higher mean OOPE of $762 (SD ±$1,421) compared to $566 (SD ±$1,880) for those without any NCDs. The total annual OOPE also increased from $295 (SD ±$977), among those without any NCDs, to $968 (SD ±$4,313) among those with three or more NCDs. Table 2 also presents the proportion of respondents with

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catastrophic health expenditure using different thresholds. The results using 10% and 25% of THE, and 40% of non-food consumption thresholds found that households with more than two NCDs had a higher proportion of catastrophic health expenditure compared to households without any member having any NCDs.

Table 4 presents the logistic regression results for the proportion of respondents who experienced catastrophic health expenditure using different thresholds. At 10% of THE as the threshold, having two NCDs increases the odds of catastrophic health expenditure to 1.58 times (95% CI 1.06–2.35), compared to having no NCDs. These odds increased to 1.69 times for those having three NCDs or more (95% CI 1.02–2.81). At the 25% and 40% thresholds, we found no significant association between the number of NCD and the incidence of catastrophic health expenditure.

Multimorbidity and productivity loss

More NCDs diagnoses were associated with greater productivity loss (Table 2, Table 5). For example, among those aged 50–60 years old, only 49.8% (95% CI 36.7–62.9) of respondents with three or more NCDs were employed, compared with 84.3% (95% CI 79.8–88.0) of respondents without NCDs (Table 2). The mean number of days of primary daily activity missed increased from 2.7 days (SD ±6.0), for those without any NCDs, to 10.1 days (SD ±12.1) for those with three or more NCDs. The mean number of days confined to bed also increased among those with three or more NCDs.

Individuals diagnosed with three or more NCDs were 0.23 times less likely (95% CI 0.16–0.33) to be employed compared to those without NCDs (Table 5). Compared with those without NCD, being diagnosed with three or more NCDs were expected to have

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a higher incidence rate of missing days of primary activity (IRR 2.59, 95% CI 1.97–3.41) as well as days spent in bed (IRR 2.64, 95% CI 1.60–4.36). We found that 48% of the variance in labour participation was due to within-individual variations, while between-individual variation accounted for 23% (1-[0.48+0.28+0.01]) (Table S3).

Robustness check

Our robustness analysis using 2014 cross-sectional dataset that consists of 14 physical NCDs (Table S4–7) showed consistent results with our original findings. Higher household expenditure and higher education were associated with greater burden of multimorbidity. Multimorbidity was also associated with higher health care use, higher incidence of catastrophic health expenditures, and lower productivity. The association between multimorbidity and catastrophic health expenditure was more pronounced in the cross-sectional analysis. Our inclusion of obesity in the clustering of multimorbidity also yields consistent results (Table S8–10).

Discussion

Our study provides the first comprehensive analysis of multimorbidity in Indonesia using the only large panel dataset in Indonesia. Our study reveals that almost one in four of our study population has at least two NCDs, with 6.5% having three or more in 2014. Our findings show a higher prevalence of multimorbidity in wealthier population groups. Multimorbidity was associated with a higher use of healthcare services, higher probability of catastrophic health expenditure, and a reduction in productivity.

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Analyses of socioeconomic gradients of NCDs in HICs routinely find negative socioeconomic gradients. However, this is not the case for LMICs, which have a more mixed pattern of the distribution of risk factors.[34,35] Other studies find a similar pattern with diabetes and cardiovascular diseases in LMICs undergoing epidemiological transition.[35] These conditions predominate in high-income quintiles in early stages of transition, which may explain our findings on the higher prevalence of NCD multimorbidity among more affluent population. We also found that obesity was more prevalent in wealthier quintiles. As obesity is associated with several NCDs (cardiovascular diseases, hypertension, stroke, cancer, arthritis and hypercholesterolemia),[36] this may explain our findings on socioeconomic gradients of NCDs. Further, our results on socioeconomic patterning of multimorbidity can be explained by the fact that higher-income and higher-educational groups have better health literacy and access to healthcare services. And thus, are more likely to have NCDs diagnosed than lower socio-income groups.

Our findings showing the association between having more NCDs and greater use of health services are in line with earlier studies from both HICs and LMICs.[9,28,37] The presence of NCD multimorbidity was also associated with a greater financial burden, which is mainly driven by higher healthcare use. These findings are consistent with earlier studies.[10,28,37,38] Based on a previous Indonesian study, four NCDs (hypertension, diabetes, heart problems, and stroke) are the leading causes of mortality and were estimated to account for 12% of Indonesia's OOPE in 2020.[22] Furthermore, the impoverishment effect of multimorbidity has been previously documented and is confirmed in our study.[7,21,22,37]

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This study contributes to the growing evidence that multimorbidity has a substantial impact on disability and productivity.[7,9,22] Interventions that can help effectively prevent and manage multimorbidity have the potential for generating substantial returns on improved health, work productivity and social benefits. However, a large portion of the Indonesia government health expenditure is still geared towards curative care.[5] Renewing the focus on health promotion and NCD prevention requires a strong PHC system.[9] PHC is the entry point of a sustainable health system for the early detection of risk factors and initiation of a treatment-seeking pathway for patients with NCDs, and thus, plays a crucial role for NCD prevention and provision of long-term integrated care. Such policies would be in line with the current program of the Ministry of Health in Indonesia to reorient public PHC to provide more promotive and preventive health services, such as through the implementation of Chronic Diseases Management Program (Prolanis) in PHC.[12,39] However, the participation in this program remains low due to the poor access to PHC facilities, especially in non-Java-Bali regions. Engaging the private sector, which makes up 60% of health facilities in Indonesia, is warranted to expand the coverage of NCD promotive and prevention activities.[40] Furthermore, the development of digital health solution and telehealth for NCDs prevention and control should be included in the national plan.[41]

Although most countries and international health organisations have recognised the importance of multimorbidity,[42] most health policies and programs still focus on single diseases, including in Indonesia. Therefore, health systems need to shift from single-disease models to new methods of financing and service delivery to more effectively manage multimorbidity.[43,44] At the primary health care level, this can be done through improved prevention and treatment of multimorbidity, underpinned by

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multidisciplinary teams lead by general practitioners.[42] There is also a need to strengthen the coordination of patient management between the primary and secondary care. Similar to many LMICs and neighbouring countries in Asia, healthcare delivery in Indonesia remains fragmented and hospital-centred, with little coordination among healthcare providers across different tiers of the system.[45]

Furthermore, under the current national health insurance scheme, the hospital reimbursement system that uses case-based groups has created significant gaps between reimbursable costs and actual hospital expenses.[46] The reimbursement system, which is mainly based on primary diagnosis, limits the hospital's capacity and willingness to treat complicated cases such as those with multimorbidity.[47] Thus, it is important to develop a clinical guideline for multimorbidity in Indonesia and other LMICs, along with payment systems that would ensure quality health services at both primary and secondary levels of care for patients with multimorbidity.[9,40] It is also worth noting that Indonesia is still facing the double burden of infectious and chronic diseases. Therefore, multimorbidity care delivery model needs to pay attention to the management of NCDs alongside infectious diseases.

There are several limitations to our study. First, the IFLS-5 was conducted between 2014 and 2015, which may not be able to capture the current prevalence of multimorbidity in Indonesia. Despite this limitation, IFLS is the only longitudinal survey available in Indonesia that is useful to produce more accurate estimates compared with using a cross-sectional dataset (e.g. the National Socioeconomic Survey). Second, our findings should be interpreted with caution since the assessment of NCDs was mostly based on self-reporting. This may cause misreporting of the true

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diagnoses and prevalence of multimorbidity. The health service use and OOPE were also based on self-reporting and may be prone to recall bias.[48] The use of self-reported diagnoses limits our assessment of the actual severity of the diseases, which may vary across socioeconomic status. Future studies should consider using different datasets (such as clinical dataset from the hospital) and applying clinical metrics such as Charlson index, which could more objectively capture disease severity and predict the health outcomes.[49] Third, the IFLS sample did not include Indonesia eastern regions. There is a need to extend the multimorbidity assessment to the remaining regions. Finally, this research intentionally focused on the older population due to a significantly higher burden of NCDs in this population group. Future research should use cohort data to follow patients over a more extended time period to examine the impact of multimorbidity and its effects in younger population groups in LMICs.[22]

Conclusion

Multimorbidity poses substantial costs to individuals, households, health system, and the wider society in Indonesia, which has an increasingly aging population. Policymakers and employers in Indonesia should carefully design and invest in targeted public health and workplace interventions at the individual and population level to avert the adverse health and economic consequences of NCD multimorbidity.

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Declarations

Abbreviation

CHE: Catastrophic health expenditure; HICs: High-income countries; IFLS: Indonesian Family Life Survey; LMICs: Low-middle income countries; NCDs: Noncommunicable diseases; OOPE: Out-of-pocket expenditure; PHC: Primary health care.

Competing interests

The authors have declared that no competing interests exist.

Ethics approval

The IFLS has been approved by ethics review boards at RAND Corporation and Gadjah Mada University in Indonesia. Written informed consent was sought from all respondents prior to data collection. As this study used IFLS publicly available datasets that contain no personal identification of the respondents, no further ethical approval was sought.

Author's contributions

Author's contributions: The aim of the research was developed by TM, KA, JL. The methodology development and analysis were conducted by TM, KA, HA, TP, JL. EH assisted in drafting the discussion section and proofread all section. YZ, HJ, MI contributed to background and discussion section. NN, BM, RA, JL provided critical input in revising the manuscript. All authors reviewed, edited and commented on multiple versions of the manuscript.

Availability of data and materials

The datasets are publicly accessible after registration (https://www.rand.org/well-being/social-and-behavioral-policy/data/FLS/IFLS/access.html).

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Figure captions

Figure 1. Prevalence of multimorbidity by age group and per capita household expenditure

[a] respondents who reported that they had 2 or more chronic conditions related to non-communicable diseases (NCDs). [b] Pooled sample of Wave 4 and Wave 5. Q1-Q5 refer to household expenditure quintiles, where Q1 is the lowest and Q5 the highest household expenditure quintile.

Tables

Table 1. Sample characteristics and factors associated with multimorbidity

Characteristics	2007		2014			
	Total n (%)	Multimorbidity % (95% CI)	Total n (%)	Multimorbidity % (95% CI)	Factors associated with multimorbidity aOR (95% CI)	p value
Overall	3678 (100%)	21.0 (19.6–22.6)	3678 (100%)	22.0 (20.6–23.6)		
Sex						
Male	1664 (46.1%)	14.1 (12.3–16.1)	1663 (46.0%)	19.4 (17.3–21.6)	1	
Female	2014 (53.9%)	26.9 (24.8–29.2)	2015 (54.0%)	24.3 (22.3–26.4)	1.74 (1.46–2.08)	<0.0001
Age						
50 – 60 years	2210 (59.8%)	19.9 (18.1–21.8)	966 (25.6%)	23.5 (20.7–26.7)	1	
61 – 70 years	1069 (29.9%)	21.9 (19.2–24.8)	1562 (42.9%)	21.6 (19.4–23.9)	1.10 (0.93–1.31)	0.257
71+ years	399 (10.3%)	25.2 (20.6–30.4)	1150 (31.4%)	21.4 (18.8–24.2)	1.09 (0.87–1.38)	0.444
Marital status						
Not currently married	927 (25.6%)	26.1 (23.0–29.4)	1338 (36.3%)	23.3 (20.9–25.9)	1	
Currently married	2751 (74.4%)	19.3 (17.7–21.1)	2340 (63.7%)	21.3 (19.5–23.2)	1.03 (0.86–1.24)	0.742
Educational level						
No education	2049 (58.7%)	20.4 (18.5–22.5)	2098 (60.6%)	18.0 (16.2–19.8)	1	
Primary	903 (24.8%)	19.7 (17.0–22.7)	862 (23.0%)	24.0 (20.9–27.3)	1.19 (0.98–1.44)	0.081
Junior high school	273 (6.4%)	25.9 (20.5–32.3)	271 (6.3%)	36.3 (30.2–43.0)	1.50 (1.12–2.02)	0.007
Senior high school	324 (7.2%)	20.5 (15.8–25.9)	307 (7.0%)	29.5 (24.1–35.5)	0.96 (0.71–1.29)	0.778
Tertiary	129 (2.9%)	34.4 (25.2–44.8)	140 (3.1%)	41.2 (31.6–51.6)	1.54 (1.01–2.34)	0.043
Ethnicity						
Javanese	1684 (51.8%)	19.4 (17.4–21.5)	1781 (55.8%)	19.7 (17.8–21.8)	1	
Sundanese	424 (15.9%)	29.1 (24.8–33.9)	438 (16.3%)	27.3 (23.1–31.8)	1.38 (1.08–1.77)	0.010
Others	1570 (32.3%)	19.6 (17,4–22.0)	1459 (27.9%)	23.6 (21.2–26.2)	1.10 (0.90–1.33)	0.355
Insurance coverage						
No	2652 (74.5%)	20.3 (18.6–22.1)	1950 (57.2%)	18.7 (16.9–20.7)	1	
Yes	1026 (25.5%)	23.2 (20.4–26.4)	1720 (42.8%)	26.4 (24.2–28.9)	1.18 (1.01–1.39)	0.035
Type of work						
Unemployed	951 (24.7%)	31.4 (28.1–34.9)	1483 (38.9%)	29.9 (27.4–32.6)	1	
Casual	674 (19.1%)	16.9 (13.9–20.4)	562 (14.1%)	13.8 (10.7–17.6)	0.47 (0.37–0.60)	<0.0001
Self-employed	1630 (45.2%)	16.8 (14.9–18.9)	1464 (40.1%)	17.4 (15.4–19.7)	0.61 (0.51–0.73)	<0.0001
Government/private	423 (10.9%)	22.2 (18.0–27.1)	269 (7.0%)	21.0 (15.8–27.4)	0.60 (0.45–0.79)	<0.0001
Per capita Household expenditure						
Q1 (the lowest)	728 (22.9%)	15.8 (13.0–18.9)	813 (25.2%)	13.5 (11.1–16.2)	1	
Q2	785 (22.4%)	17.9 (15.1–21.2)	746 (21.4%)	18.9 (15.9–22.3)	1.28 (1.01–1.62)	0.040
Q3	743 (20.1%)	20.5 (17.4–24.0)	757 (20.4%)	22.1 (18.9–25.7)	1.37 (1.08–1.74)	0.009
Q4	744 (18.4%)	23.6 (20.3–27.3)	681 (17.2%)	25.3 (21.9–29.0)	1.84 (1.44–2.33)	<0.0001
Q5 (the highest)	678 (16.1%)	30.4 (26.5–34.7)	681 (15.8%)	36.2 (32.2–40.5)	2.22 (1.72–2.86)	<0.0001
Residency						
Rural	1958 (63.4%)	18.1 (16.3–20.1)	1682 (52.8%)	16.9 (15.1–19.0)	1	
Urban	1720 (36.6%)	26.1 (23.8–28.6)	1996 (47.1%)	27.7 (25.5–30.0)	1.41 (1.19–1.67)	<0.0001
Region						
Java-Bali	2413 (77.5%)	21.6 (19.9–23.5)	2417 (77.6%)	21.1 (19.3–22.9)	1	
Sumatra	691 (14.5%)	19.6 (16.7–22.8)	690 (14.5%)	26.6 (23.3–30.2)	1.06 (0.85–1.33)	0.602
Nusa Tenggara	239 (2.4%)	14.5 (10.6–19.5)	239 (2.4%)	14.5 (10.5–19.6)	0.59 (0.40–0.87)	0.008
Kalimantan	168 (1.8%)	17.9 (12.7–24.5)	168 (1.7%)	34.2 (27.4–41.7)	1.35 (0.92–1.98)	0.129
Sulawesi	167 (3.8%)	19.6 (14.1–26.6)	164 (3.7%)	23.7 (17.6–31.0)	0.89 (0.59–1.34)	0.569

[a] Values are unweighted counts and weighted percentages unless otherwise indicated

[b] We defined multimorbidity if the respondents reported that they had 2 or more chronic conditions related to NCDs. Chronic diseases included: hypertension, diabetes, asthma, heart attack/coronary heart diseases, liver disease, stroke, cancer, arthritis/rheumatism, hypercholesterolemia, and mental illness.

[c] Adjusted odds ratio (aOR) was estimated using multilevel logistic regression model of 2007 and 2014 IFLS

NCD: noncommunicable disease

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Table 2. Descriptive summary of health service use-financial burden and productivity outcomes by the number of NCDs (2014 IFLS)

	No NCD	1 NCD	2 NCDs	+3 NCDs
	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
Overall (n, %)	1052 (100%)	1751 (100%)	627 (100%)	248 (100%)
Health service use				
Outpatient services [a)]				
Any visit (%, 95% CI)	15.5% (13.3–17.9)	21.7% (19.5–23.9)	35.7% (31.7–40.0)	55.9% (49.0–62.6)
Number of visits (mean, SD)	0.24 ± 0.72	0.41 ± 1.1	0.78 ± 1.6	1.4 ± 2.1
Inpatient services [b)]				
Any visit (%, 95% CI)	3.3% (2.3–4.8)	4.6% (3.5–6.0)	8.3% (6.1–11.0)	20.8% (15.7–27.0)
Number of visits (mean, SD)	0.04 ± 0.30	0.06 ± 0.31	0.14 ± 0.65	0.35 ± 0.96
Financial burden				
OOPE for outpatient care (mean, SD) [a,c)]	$17 ± 47	$17 ± 58	$15 ± 40	$60 ± 321
OOPE for inpatient care (mean, SD) [b,c)]	$566 ± 1,880	$527 ± 2,115	$792 ± 1,706	$762 ± 1,421
Annual Total OOPE (mean, SD)	$295 ± 977	$292 ± 1,239	$336 ± 950	$968 ± 4,313
Catastrophic health expenditure (%, 95% CI)				
>10% of total household expenditure	5.0% (3.7–6.6)	6.9% (5.6–8.5)	10.3% (7.9–13.4)	12.5% (8.7–17.7)
>25% of total household expenditure	1.5% (8.6–2.5)	1.5% (0.9–2.3)	2.8% (1.6–4.8)	2.8% (1.3–6.3)
>40% of total non-food expenditure	1.8% (1.1–2.8)	2.7% (1.9–3.6)	4.0% (2.6–6.2)	3.6% (1.8–6.8)
Productivity loss				
Labour participation (%, 95% CI)				
50-60 years[d)]	84.3% (79.8–88.0)	74.3% (69.3–7.8)	72.3% (64.3–79.1)	49.8% (36.7–62.9)
61-70 years [d)]	78.3% (74.0–82.1)	65.2% (61.1–69.1)	54.3% (47.1–61.3)	42.8% (32.6–53.8)
71+ years[d)]	51.4% (44.7–58.1)	45.0% (40.5–49.5)	28.4% (21.6–36.3)	17.3% (8.1–33.4)
Number of days of primary activity missed (mean, SD)	2.7 ± 6.0	3.6 ± 6.8	6.5 ± 9.8	10.1 ± 12.1
Number of days lying in bed (mean, SD)	0.80 ± 3.4	0.99 ± 3.6	1.9 ± 6.0	2.4 ± 6.3

[a)] in the last four weeks
[b)] in the last 12 months
[c)] Out-of-pocket expenditure (OOPE) were only asked to those who utilised outpatient and/or inpatient services.
[d)] The percentages were calculated based on the total number of respondents by aged groups. Total respondents aged 50-60 years, 61-70 years and 71+ years are 966, 1592, and 1150 respondents.
OOPE medical expenses were converted to 2014 International Dollars (INT$).
Bootstrapping with 400 times replications was performed to estimate the standard error and 95% CI.

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637 **Table 3. The effect of multimorbidity on health service use**

Variables	Health service use							
	Outpatient				Inpatient			
	Any visit[a)]		Number of visits[b)]		Any visit[a)]		Number of visits[b)]	
	aOR (95% CI)	p values	IRR (95% CI)	p values	aOR (95% CI)	p values	IRR (95% CI)	p values
Number of NCDs (ref. no NCD)								
Single NCD	1.35 (1.15–1.58)	<0.0001	1.45 (1.24–1.69)	<0.0001	1.07 (0.78–1.48)	0.671	1.06 (0.75–1.50)	0.755
Two NCDs	2.43 (2.00–2.95)	<0.0001	2.45 (2.04–2.93)	<0.0001	1.78 (1.23–2.57)	0.002	2.07 (1.39–3.08)	<0.0001
Three or more NCDs	4.66 (3.55–6.11)	<0.0001	4.25 (3.33–5.42)	<0.0001	3.69 (2.35–5.79)	<0.0001	3.68 (2.21–6.12)	<0.0001
Period (ref. 2007)								
2014	1.40 (1.22–1.61)	<0.0001	1.46 (1.29–1.65)	<0.0001	1.79 (1.36–2.36)	<0.0001	2.20 (1.63–2.98)	<0.0001
Sex (ref. Male)								
Female	1.26 (1.08–1.47)	0.003	1.20 (1.04–1.39)	0.013	0.93 (0.70–1.24)	0.626	0.85 (0.62–1.16)	0.300
Age (ref. 50 – 60 years)								
61 – 70 years	1.01 (0.86–1.18)	0.905	1.00 (0.87–1.16)	0.969	1.07 (0.78–1.45)	0.677	1.17 (0.84–1.65)	0.351
71+ years	1.10 (0.90–1.34)	0.351	1.06 (0.88–1.27)	0.567	1.49 (1.03–2.15)	0.034	1.66 (1.11–2.49)	0.014
Marital status (ref. Not married)								
Currently married	1.14 (0.97–1.34)	0.105	1.15 (0.99–1.34)	0.069	1.04 (0.77–1.40)	0.815	0.98 (0.71–1.37)	0.914
Educational level (ref. No education)								
Primary	1.06 (0.90–1.25)	0.496	0.96 (0.82–1.13)	0.629	1.09 (0.80–1.50)	0.578	0.97 (0.69–1.38)	0.882
Junior high school	1.04 (0.80–1.35)	0.786	1.00 (0.78–1.28)	0.993	1.23 (0.78–1.95)	9,40 0.368	1.48 (0.90–2.42)	0.120
Senior high school	1.05 (0.81–1.36)	0.706	0.91 (0.71–1.17)	0.473	0.91 (0.57–1.46)	0.699	0.82 (0.49–1.37)	0.448
Tertiary	1.29 (0.90–1.84)	0.167	0.93 (0.66–1.32)	0.697	0.98 (0.53–1.80)	0.937	0.85 (0.42–1.69)	0.640
Ethnicity (ref. Javanese)								
Sundanese	0.92 (0.74–1.14)	0.464	0.95 (0.77–1.16)	0.617	0.90 (0.61–1.34)	0.609	1.14 (0.75–1.76)	0.536
Others	1.06 (0.89–1.25)	0.525	0.99 (0.84–1.16)	0.877	0.90 (0.65–1.23)	0.495	1.08 (0.76–1.52)	0.676
Insurance coverage (ref. No)								
Yes	1.48 (1.28–1.70)	<0.0001	1.51 (1.32–1.72)	<0.0001	1.90 (1.45–2.50)	<0.0001	1.65 (1.23–2.21)	0.001
Type of work (ref. Unemployed)								
Casual	0.76 (0.62–0.95)	0.014	0.69 (0.57–0.85)	<0.0001	0.49 (0.31–0.78)	0.003	0.44 (0.27–0.73)	0.001
Self-employed	0.85 (0.73–1.00)	0.056	0.82 (0.70–0.95)	0.008	0.60 (0.44–0.82)	0.001	0.60 (0.43–0.83)	0.002
Government/private	0.75 (0.58–0.96)	0.025	0.72 (0.57–0.92)	0.008	0.63 (0.39–1.04)	0.071	0.77 (0.46–1.31)	0.335
Per capita household expenditure (ref. Q1)								
Q2	1.50 (1.21–1.86)	<0.0001	1.50 (1.23–1.84)	<0.0001	1.25 (0.81–1.92)	0.307	1.07 (0.67–1.70)	0.777
Q3	1.76 (1.42–2.18)	<0.0001	1.74 (1.42–2.13)	<0.0001	1.64 (1.08–2.49)	0.020	1.71 (1.10–2.66)	0.018
Q4	1.73 (1.38–2.15)	<0.0001	1.80 (1.46–2.21)	<0.0001	1.42 (0.91–2.20)	0.121	1.36 (0.86–2.18)	0.192
Q5	1.90 (1.51–2.40)	<0.0001	2.09 (1.68–2.59)	<0.0001	2.48 (1.60–3.85)	<0.0001	2.52 (1.59–4.00)	<0.0001
Residency (ref. Rural)								
Urban	0.92 (0.80–1.07)	0.283	0.95 (0.83–1.10)	0.500	0.96 (0.72–1.26)	0.744	1.05 (0.78–1.42)	0.726
Region (ref. Java-Bali)								
Sumatra	0.83 (0.68–1.00)	0.052	0.98 (0.81–1.17)	0.798	1.23 (0.87–1.74)	0.236	1.25 (0.86–1.82)	0.250
Nusa Tenggara	0.64 (0.46–0.89)	0.007	0.60 (0.43–0.82)	0.002	1.25 (0.71–2.18)	0.437	1.11 (0.60–2.03)	0.745
Kalimantan	1.03 (0.74–1.43)	0.873	1.21 (0.89–1.65)	0.228	1.09 (0.58–2.05)	0.799	0.94 (0.47–1.89)	0.865
Sulawesi	0.64 (0.45–0.93)	0.019	0.63 (0.44–0.90)	0.011	0.63 (0.30–1.35)	0.235	0.63 (0.29–1.38)	0.249

[a)] Multilevel logistic regression model
[b)] Multilevel negative binomial regression model
aOR: adjusted odds ratio, IRR: Incidence rate ratio, NCD: noncommunicable disease

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639 **Table 4. The effect of multimorbidity on catastrophic expenditure**

Variables	Catastrophic health expenditure					
	10% of total household expenditure[a)]		25% of total household expenditure[a)]		40% of non-food expenditure [a)]	
	aOR (95% CI)	p values	aOR (95% CI)	p values	aOR (95% CI)	p values
Number of NCDs (ref. no NCD)						
Single NCD	1.11 (0.76–1.62)	0.591	0.81 (0.49–1.34)	0.417	0.86 (0.52–1.43)	0.561
Two NCDs	1.58 (1.06–2.35)	0.026	1.39 (0.79–2.45)	0.250	1.27 (0.69–2.35)	0.437
Three or more NCDs	1.69 (1.02–2.81)	0.042	0.96 (0.40–2.34)	0.937	0.72 (0.27–1.89)	0.503
Period (ref. 2007)						
2014	1.42 (1.12–1.80)	0.003	1.27 (0.83–1.95)	0.271	1.18 (0.77–1.80)	0.442
Sex (ref. Male)						
Female	0.89 (0.64–1.23)	0.480	0.90 (0.57–1.42)	0.645	0.83 (0.52–1.33)	0.432
Age (ref. 50 – 60 years)						
61 – 70 years	1.15 (0.79–1.69)	0.461	1.46 (0.90–2.36)	0.125	1.43 (0.85–2.38)	0.175
71+ years	1.13 (0.66–1.92)	0.663	1.01 (0.51–2.01)	0.975	1.24 (0.60–2.55)	0.563
Marital status (ref. Not married)						
Currently married	1.59 (1.22 – 2.09)	0.001	1.68 (0.98–2.87)	0.060	1.83 (1.01–3.33)	0.047
Educational level (ref. No education)						
Primary	0.96 (0.67–1.38)	0.841	0.90 (0.52–1.55)	0.708	0.85 (0.48–1.52)	0.589
Junior high school	0.97 (0.64–1.47)	0.902	1.21 (0.58–2.55)	0.610	0.60 (0.25–1.48)	0.271
Senior high school	0.93 (0.61–1.42)	0.735	1.22 (0.59–2.52)	0.595	0.81 (0.34–1.92)	0.627
Tertiary	0.45 (0.22–0.90)	0.023	0.11 (0.01–0.94)	0.043	0.12 (0.02–0.84)	0.032
Ethnicity (ref. Javanese)						
Sundanese	0.87 (0.62–1.23)	0.433	1.80 (0.98–3.33)	0.060	1.14 (0.52–2.48)	0.748
Others	0.76 (0.56–1.02)	0.065	1.01 (0.58–1.78)	0.959	0.56 (0.28–1.09)	0.088
Insurance coverage (ref. No)						
Yes	0.89 (0.67–1.20)	0.451	0.83 (0.53–1.31)	0.425	0.80 (0.49–1.32)	0.390
Type of work (ref. Unemployed)						
Casual	0.59 (0.33–1.07)	0.082	0.58 (0.29–1.17)	0.128	0.41 (0.20–0.84)	0.015
Self-employed	0.60 (0.36–1.01)	0.056	0.58 (0.35–0.96)	0.033	0.45 (0.27–0.76)	0.003
Government/private	0.58 (0.34–1.02)	0.058	0.78 (0.35–1.70)	0.527	0.39 (0.16–0.95)	0.038
Per capita household expenditure (ref. Q1)						
Q2	1.04 (0.071- 1.52)	0.834	1.60 (0.71–3.57)	0.257	1.34 (0.62–2.90)	0.459
Q3	1.37 (0.97–1.95)	0.076	1.71 (0.77–3.80)	0.188	1.19 (0.54–2.61)	0.669
Q4	1.98 (1.40–2.81)	<0.0001	3.11 (1.43–6.76)	0.004	2.73 (1.23–6.03)	0.013
Q5	3.13 (2.28–4.31)	<0.0001	5.91 (2.72–12.85)	<0.0001	8.45 (3.70–19.32)	<0.0001
Residency (ref. Rural)						
Urban	0.94 (0.61–1.45)	0.785	0.76 (0.46–1.24)	0.273	0.75 (0.43–1.31)	0.309
Region (ref. Java-Bali)						
Sumatra	0.78 (0.56–1.09)	0.146	0.73 (0.38–1.38)	0.328	1.08 (0.52–2.24)	0.846
Nusa Tenggara	0.64 (0.34 – 1.21)	0.175	0.98 (0.32–2.99)	0.968	0.93 (0.22–3.83)	0.917
Kalimantan	0.78 (0.39–1.52)	0.460	0.64 (0.19–2.24)	0.488	0.64 (0.15–2.77)	0.548
Sulawesi	0.80 (0.43–1.48)	0.478	1.21 (0.41–3.57)	0.724	1.31 (0.33–5.17)	0.701

[a)] Multilevel logistic regression model

aOR: adjusted odds ratio, NCD: noncommunicable disease

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641 **Table 5. The effect of multimorbidity on productivity loss**

Variables	Productivity loss					
	Labour participation[a)]		Days primary activity missed[b)]		Days stayed in bed[b)]	
	aOR (95% CI)	p values	IRR (95% CI)	p values	IRR (95% CI)	p values
Number of NCDs (ref. no NCD)						
Single NCD	0.65 (0.54–0.79)	<0.0001	1.25 (1.08–1.43)	0.002	1.09 (0.84–1.43)	0.509
Two NCDs	0.45 (0.35–0.57)	<0.0001	1.90 (1.58–2.29)	<0.0001	1.87 (1.33–2.61)	<0.0001
Three or more NCDs	0.23 (0.16–0.33)	<0.0001	2.59 (1.97–3.41)	<0.0001	2.64 (1.60–4.36)	<0.0001
Period (ref. 2007)						
2014	0.69 (0.59–0.81)	<0.0001	1.66 (1.46–1.88)	<0.0001	1.79 (1.40–2.29)	<0.0001
Sex (ref. Male)						
Female	0.21 (0.17–0.26)	<0.0001	0.99 (0.86–1.14)	0.912	0.92 (0.70–1.21)	0.567
Age (ref. 50 – 60 years)						
61 – 70 years	0.37 (0.31–0.45)	<0.0001	0.99 (0.86–1.14)	0.859	1.07 (0.81–1.41)	0.617
71+ years	0.10 (0.07–0.13)	<0.0001	1.20 (1.00–1.44)	0.047	1.93 (1.37–2.72)	<0.0001
Marital status (ref. Not married)						
Currently married	1.51 (1.23–1.84)	<0.0001	1.13 (0.98–1.31)	0.089	0.88 (0.67–1.17)	0.395
Educational level (ref. No education)						
Primary	0.89 (0.71–1.11)	0.305	0.92 (0.79–1.07)	0.263	1.00 (0.75–1.33)	0.999
Junior high school	0.41 (0.29–0.57)	<0.0001	0.94 (0.74–1.20)	0.631	0.87 (0.54–1.40)	0.570
Senior high school	0.41 (0.29–0.58)	<0.0001	0.68 (0.53–0.87)	0.002	0.81 (0.51–1.28)	0.362
Tertiary	0.51 (0.31–0.82)	0.006	0.54 (0.38–0.78)	0.001	0.37 (0.18–0.78)	0.009
Ethnicity (ref. Javanese)						
Sundanese	0.50 (0.37–0.67)	<0.0001	1.35 (1.11–1.65)	0.003	1.28 (0.89–1.85)	0.179
Others	0.77 (0.61–0.98)	0.033	1.11 (0.95–1.30)	0.188	1.12 (0.84–1.49)	0.436
Insurance coverage (ref. No)						
Yes	0.85 (0.72–1.01)	0.071	1.08 (0.95–1.22)	0.258	1.05 (0.82–1.34)	0.704
Type of work (ref. Unemployed)						
Casual	N/A	N/A	0.62 (0.51–0.75)	<0.0001	0.32 (0.22–0.47)	<0.0001
Self-employed	N/A	N/A	0.62 (0.53–0.71)	<0.0001	0.42 (0.32–0.56)	<0.0001
Government/private	N/A	N/A	0.57 (0.45–0.72)	<0.0001	0.45 (0.28–0.73)	0.001
Per capita household expenditure (ref. Q1)						
Q2	1.37 (1.08–1.75)	0.011	1.03 (0.86–1.23)	0.744	1.05 (0.74–1.49)	0.769
Q3	1.33 (1.03–1.71)	0.028	1.15 (0.96–1.38)	0.130	1.06 (0.75–1.50)	0.737
Q4	1.12 (0.87–1.46)	0.379	1.05 (0.87–1.27)	0.627	1.02 (0.71–1.46)	0.914
Q5	1.34 (1.01–1.77)	0.043	1.29 (1.05–1.58)	0.015	0.92 (0.63–1.35)	0.668
Residency (ref. Rural)						
Urban	0.44 (0.35–0.54)	<0.0001	0.93 (0.81–1.07)	0.296	0.70 (0.54–0.89)	0.004
Region (ref. Java-Bali)						
Sumatra	0.95 (0.73–1.25)	0.735	1.13 (0.94–1.–36)	0.194	1.01 (0.73–1.40)	0.956
Nusa Tenggara	0.74 (0.48–1.14)	0.177	0.90 (0.68–1.20)	0.472	1.14 (0.67–1.93)	0.638
Kalimantan	1.21 (0.75–1.94)	0.440	0.90 (0.67–1.22)	0.511	0.89 (0.51–1.57)	0.688
Sulawesi	0.39 (0.24–0.62)	<0.0001	0.99 (0.72–1.36)	0.948	0.94 (0.53–1.69)	0.845

[a)] Multilevel logistic regression model
[b)] Multilevel negative binomial regression model
aOR: adjusted odds ratio, IRR: incidence rate ratio, NCD: noncommunicable disease

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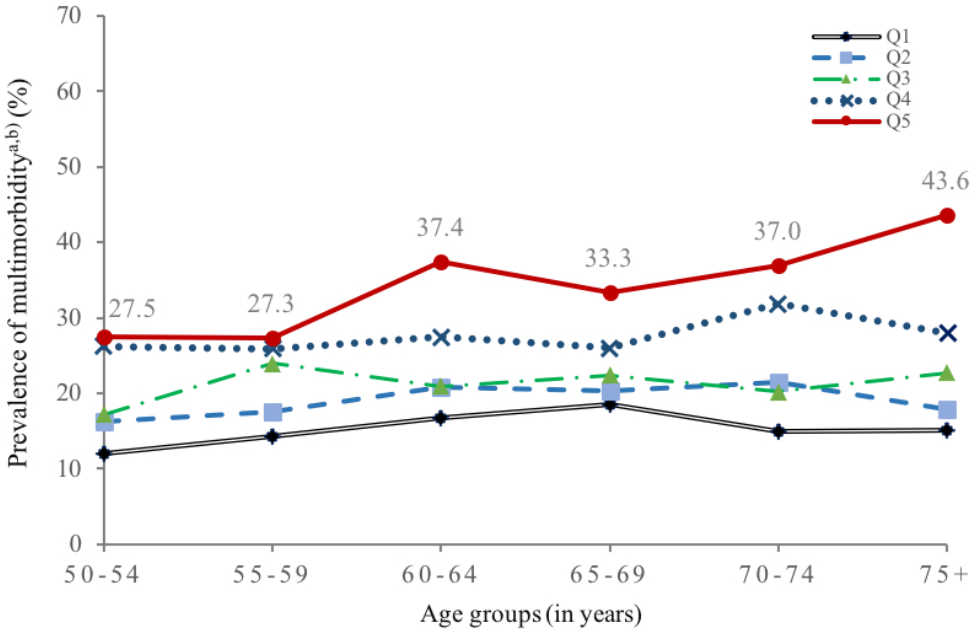

Figure 1. Prevalence of multimorbidity by age group and per capita household expenditure
a) respondents who reported that they had 2 or more chronic conditions related to non-communicable diseases (NCDs). b) Pooled sample of Wave 4 and Wave 5. Q1-Q5 refer to household expenditure quintiles, where Q1 is the lowest and Q5 the highest household expenditure quintile.

137x91mm (150 x 150 DPI)

SUPPLEMENTAL MATERIAL

Figure S1. Sample flowchart

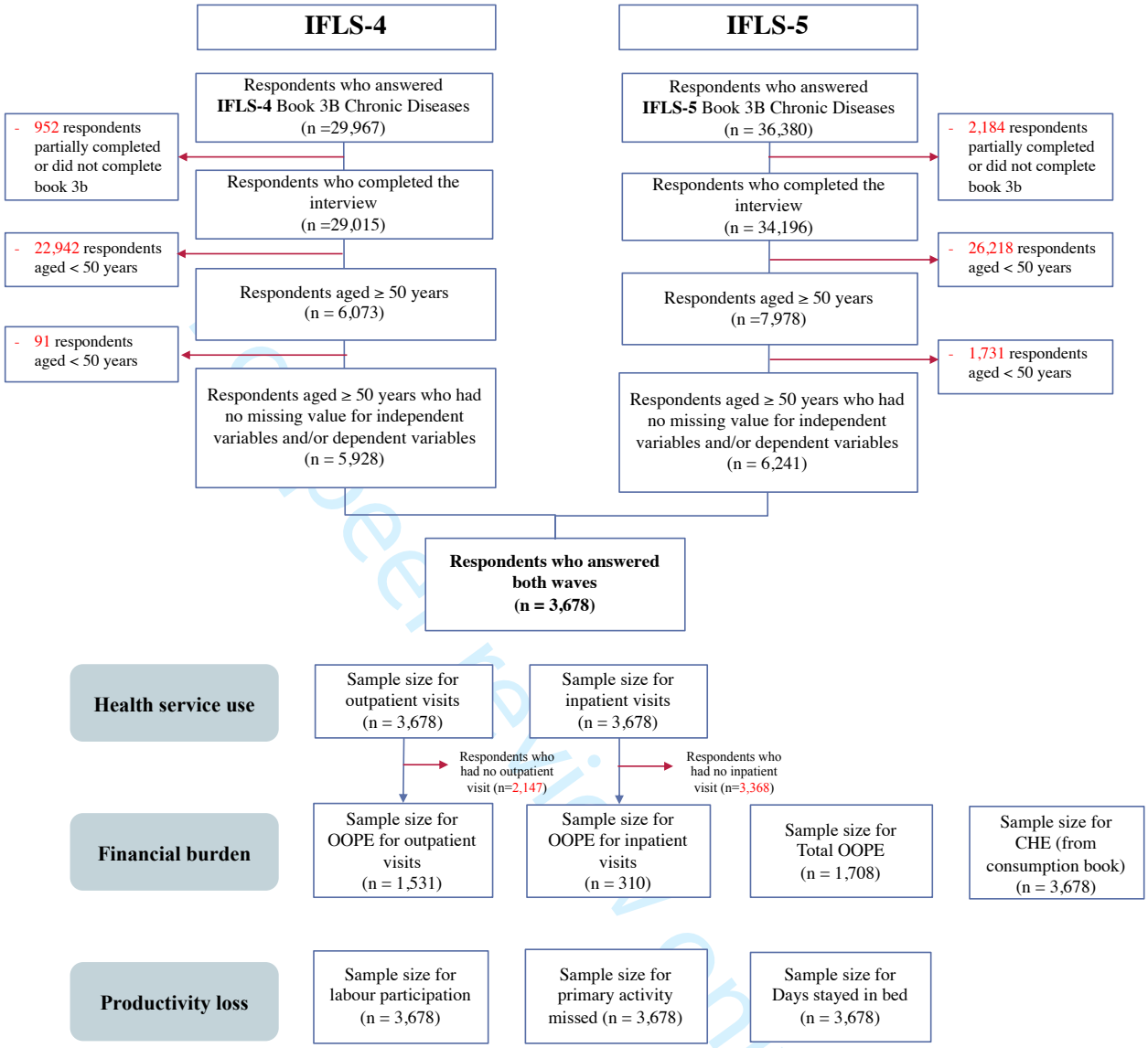

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Table S1. List of variables for 2007 & 2014 IFLS analysis

Variables	Type	Measurement	Source of measurement
Dependent variables:			
1) Health service use			
Outpatient care	Binary	0. No 1. Yes	RJ00: In the last 4 weeks have you visited a public hospital-*puskesmas*-private hospital-clinic-health worker or doctor's practice or been visited by a health worker or doctor?
	Numerical	Number of days	RJ02: How many times did you visit / been visited by [...] during the last 4 weeks?
Inpatient care	Binary	0. No 1. Yes	RN00: During the past 12 months have you ever received patient care at a hospital-*puskesmas*-clinic-or other?
	Numerical	Number of days	RN02: How many times have you received inpatient care at […] during the past 12 months?
2) Productivity loss			
Labour participation	Binary	0. No 1. Yes	TK06a: Did you work/try to work/help to earn income for pay for at least 1 hour during the past week?
	Numerical	Number of days	
Activity missed due to poor health	Numerical	Number of days	KK02a: During the last 4 weeks-how many days of your primary daily activities did you miss due to poor health?
Stayed in bed	Numerical	Number of days	KK02b: In the last 4 weeks-how many days have you stayed in bed due to poor health?
3) Financial burden			
OOPE of outpatient care	Numerical	International Dollars	RJ02b: How much did you pay out of pocket for outpatient care at […] during the past 4 weeks?
OOPE of inpatient care	Numerical	International Dollars	RN02b: How much did you pay out of pocket for inpatient care at […] during the past 12 months?
Annual Total OOPE	Numerical	International Dollars	Annual total OOPE for outpatient and inpatient visits
Catastrophic health expenditure	Binary	0. No 1. Yes	Book KS: "How much money spent by all household members for medical costs during the past year?"
Main independent variable			
Number of NCDs	Numerical	Total number of chronic conditions related to NCDs	Book IIIB: CD06a – CD06r: Have a doctor/paramedic/nurse/ midwife ever told you that you had [list of chronic diseases]
	Categorical ordinal	2. No 3. 1 NCD 4. 2 NCDs	

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Variables	Type	Measurement	Source of measurement
		5. 3+ NCDs	
Multimorbidity	Binary	0. No 1. Yes (had 2 or more chronic conditions related to NCDs)	Book IIIB: CD06a – CD06r: Have a doctor/paramedic/nurse/ midwife ever told you that you had [list of chronic diseases]
List of chronic diseases included in the main analysis: Hypertension, diabetes, asthma, heart attack/coronary heart diseases, liver disease, stroke, cancer, arthritis/rheumatism, hypercholesterolemia, and depression/mental illness. List of chronic diseases in 2007 IFLS (Wave 4): Hypertension, diabetes, asthma, heart attack/coronary heart diseases, liver disease, stroke, cancer, arthritis/rheumatism, hypercholesterolemia, and depression/mental illness. List of chronic diseases in 2014 IFLS (Wave 5): Hypertension, diabetes, asthma, heart attack/coronary heart diseases, liver disease, stroke, cancer, arthritis/rheumatism, hypercholesterolemia, mental illness, prostate diseases, kidney diseases (excluding malignancy), digestive diseases, and memory-related diseases.			
Covariates			
Age (in years)	Categorical ordinal	0. 40-49 years 1. 50-59 years 2. 60-69 years 3. 70-79 years 4. 80+	Book IIIA: Age: How old are you?
Sex	Binary	0. Male 1. Female	Book IIIA: Sex: (identified by interviewers)
Ethnicity	Categorical nominal	0. Javanese 1. Sundanese 2. Others	
Marital status	Binary	0. Unmarried/Divorce 1. Married or living together	Book IIIA HR00b: Are you currently married?
Education	Categorical ordinal	0. None 1. Elementary school 2. Junior high school 3. High school 4. Tertiary	Book IIIA: DL06: What is the highest education level attended? DL07: What is the highest grade completed at school.
Occupation	Categorical nominal	0. None 1. Casual worker 2. Self-employed 3. Government/private worker	Book IIIA: TK06a: Did you work/try to work/help to earn income for pay for at least 1 hour during the past week? TK15: Which category best describes the work you did in your last job?
Health insurance status	Binary	0. Uninsured (Not covered by any insurance) 1. Insured	Book IIIB: AK01: Are you the policy holder/primary beneficiary of health benefits-health insurance?
Per capita expenditure	Categorical ordinal	0. Q1 (lowest) 1. Q2 2. Q3 3. Q4 4. Q5 (highest)	Book KS
Residency	Binary	0. Rural 1. Urban	Book T-2: SC06: (identified by interviewers)
Region	Categorical nominal	0. Java-Bali 1. Sumatra 2. Nusa Tenggara 3. Kalimantan 4. Sulawesi	Book T-2: SC01: province (identified by interviewers)

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Table S2. Sample characteristics by number of NCDs

Characteristics	2007 (n=3,678)			2014 (n=3,678)		
	Zero NCD (n=1,272)	One NCD (n=1,605)	Multimorbidity (n=801)	Zero NCD (n=1,052)	One NCD (n=1,751)	Multimorbidity (n=875)
Sex						
Male	44.2 (41.5–46.9)	41.7 (39.1–44.5)	14.1 (12.3–16.1)	34.7 (32.1–37.3)	45.9 (43.2–48.7)	19.3 (17.3–21.6)
Female	28.9 (26.7–31.3)	44.2 (41.7–46.7)	26.9 (24.8–29.2)	24.6 (22.5–26.8)	51.1 (48.6–53.6)	24.3 (22.3–26.4)
Age						
50 – 60 years	39.9 (37.55–42.2)	40.3 (38.0–42.6)	19.9 (18.1–21.8)	36.4 (33.0–39.9)	40.1 (36.6–43.7)	23.5 (20.7–26.7)
61 – 70 years	32.3 (29.1–35.6)	45.9 (42.5–49.3)	21.9 (19.2–24.8)	30.2 (27.7–32.9)	48.2 (45.4–51.0)	21.6 (19.4–23.9)
71+ years	23.9 (19.2–29.3)	50.9 (45.2–56.6)	25.2 (20.6–30.4)	22.0 (19.4–25.0)	56.6 (53.2–59.8)	21.4 (18.8–24.2)
Marital status						
Not currently	25.6 (22.5–29.0)	48.3 (44.6–52.0)	26.1 (23.0–29.4)	23.8 (21.2–26.5)	52.9 (49.9–56.0)	23.3 (20.9–25.9)
married	39.5 (37.4–41.6)	41.2 (39.1–43.4)	19.3 (17.7–21.1)	32.4 (30.2–34.6)	46.3 (44.0–48.7)	21.3 (19.5–23.2)
Currently married						
Educational level						
No education	24.8 (32.5–37.2)	44.8 (42.3–47.2)	20.4 (18.5–22.5)	29.6 (27.4–31.9)	52.4 (50.0–54.8)	18.0 (16.2–19.8)
Primary	40.5 (36.9–44.2)	39.8 (36.2–46/3)	19.7 (17.0–22.7)	28.6 (25.3–32.1)	47.5 (43.7–51.3)	24.0 (20.9–27.3)
Junior high school	34.4 (28.3–41.1)	39.6 (33.4–46.3)	25.9 (20.5–32.3)	31.6 (25.6–38.3)	32.1 (26.1–38.7)	36.3 (30.2–43.0)
Senior high school	35.9 (30.2–42.1)	43.6 (37.5–49.8)	20.5 (15.8–25.9)	28.9 (23.4–35.0)	41.6 (35.6–48.0)	29.5 (24.1–35.5)
Tertiary	23.7 (16.2–33.2)	41.9 (32.1–52.4)	34.4 (25.2–44.8)	23.0 (15.8–32.2)	35.7 (27.0–45.5)	41.2 (31.6–51.6)
Ethnicity						
Javanese	37.0 (34.5–39.6)	43.6 (41.0–46.2)	19.4 (17.4–21.5)	29.7 (27.4–32.1)	50.6 (48.1–53.2)	19.7 (17.8–21.8)
Sundanese	30.4 (25.9–35.2)	40.5 (35.7–45.5)	29.1 (24.8–33.9)	23.5 (19.6–27.9)	49.3 (44.3–54.2)	27.3 (23.1–31.8)
Others	37.0 (34.2–39.9)	43.4 (40.5–46.3)	19.6 (17,4–22.0)	31.7 (29.0–34.7)	44.6 (41.6–47.7)	23.6 (21.2–26.2)
Insurance coverage						
No	36.5 (34.4–38.6)	43.2 (41.1–45.4)	20.3 (18.6–22.1)	31.1 (28.9–33.5)	50.2 (47.7–52.7)	18.7 (16.9–20.7)
Yes	34.2 (30.9–37.7)	42.5 (39.1–46.0)	23.2 (20.4–26.4)	26.7 (24.3–29.2)	46.8 (44.1–49.6)	26.4 (24.2–28.9)
Type of work						
Unemployed	22.5 (19.6–25.6)	46.2 (42.6–49.8)	31.4 (28.1–34.9)	19.6 (17.4–22.1)	50.4 (47.5–53.3)	29.9 (27.4–32.6)
Casual	41.8 (37.6–46.1)	41.3 (37.2–45.6)	16.9 (13.9–20.4)	36.5 (31.6–41.6)	49.7 (44.6–54.8)	13.8 (10.7–17.6)
Self-employed	41.1 (38.4–43.9)	42.1 (39.4–44.8)	16.8 (14.9–18.9)	34.2 (31.5–37.0)	48.4 (45.4–51.3)	17.4 (15.4–19.7)
Government/priva	34.8 (29.8–40.2)	43.0 (37.7–48.4)	22.2 (18.0–27.1)	39.6 (33.0–46.5)	39.4 (32.9–46.3)	21.0 (15.8–27.4)
te						
Household						
expenditure						
Q1 (the lowest)	39.9 (36.0–43.9)	44.1 (40.1–48.1)	15.8 (13.0–18.9)	30.9 (27.5–34.6)	55.6 (51.8–59.3)	13.5 (11.1–16.2)
Q2	39.6 (35.7–43.6)	42.4 (38.6–46.4)	17.9 (15.1–21.2)	31.6 (27.9–35.5)	49.5 (45.4–53.6)	18.9 (15.9–22.3)
Q3	36.4 (32.5–40.5)	43.1(39.1–47.2)	20.5 (17.4–24.0)	31.4 (27.7–35.3)	46.5 (42.5–50.6)	22.1 (18.9–25.7)
Q4	31.7 (27.9–35.7)	44.6 (40.5–48.7)	23.6 (20.3–27.3)	27.0 (23.3–31.1)	47.8 (43.4–52.1)	25.3 (21.9–29.0)
Q5 (the highest)	28.8 (24.9–33.0)	40.5 (36.3–44.9)	30.4 (26.5–34.7)	23.1 (19.6–27.0)	40.7 (36.5–45.0)	36.2 (32.2–40.5)
Residency						
Rural	38.7 (36.3–41.1)	43.2 (40.8–45.7)	18.1 (16.3–20.1)	31.0 (28.6–33.5)	52.1 (49.4–54.7)	16.9 (15.1–19.0)
Urban	31.2 (28.7–33.7)	42.7 (40.1–45.4)	26.1 (23.8–28.6)	27.3 (25.1–29.6)	45.0 (42.5–47.5)	27.7 (25.5–30.0)
Island						
Java-Bali	36.5 (34.4–38.7)	41.9 (39.7–44.1)	21.6 (19.9–23.5)	29.7 (27.7–31.7)	49.3 (47.1–51.5)	21.1 (19.3–22.9)
Sumatra	34.6 (31.0–38.4)	45.9 (42.0–49.8)	19.6 (16.7–22.8)	27.9 (24.6–31.6)	45.4 (41.6–49.4)	26.6 (23.3–30.2)
Nusa Tenggara	44.0 (37.7–50.5)	41.6 (35.3–48.1)	14.5 (10.6–19.5)	31.4 (25.7–37.7)	54.1 (47.6–60.5)	14.5 (10.5–19.6)
Kalimantan	25.2 (19.2–32.4)	56.9 (49.0–64.4)	17.9 (12.7–24.5)	23.4 (17.6–30.6)	42.4 (35.0–50.1)	34.2 (27.4–41.7)
Sulawesi	30.0 (23.3–37.6)	50.4 (42.6–58.2)	19.6 (14.1–26.6)	26.7 (20,3–34.2)	49.7 (41.8–57.5)	23.7 (17.6–31.0)
Overall (N, %)	1,272 (35.9)	1,605 (43.0)	801 (21.0)	1,052 (29.2)	1,751 (48.7)	875 (22.0)

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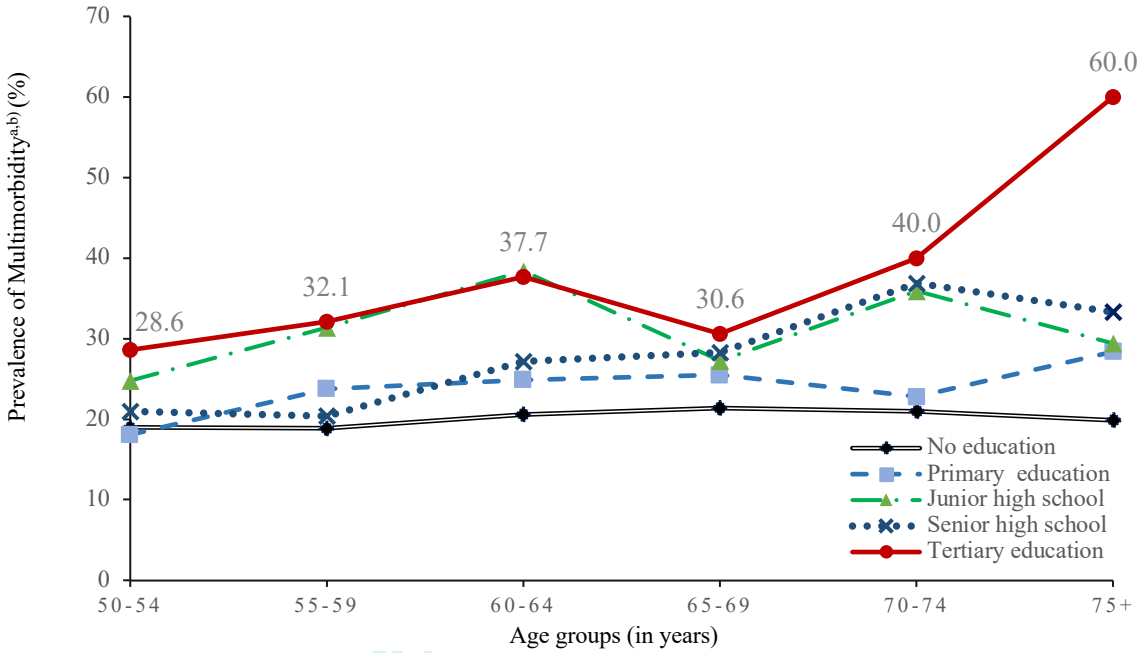
Figure S2. Prevalence of multimorbidity by age group and level of education



[a)] respondents who reported that they had 2 or more chronic conditions related to noncommunicable diseases (NCDs). [b)] Pooled sample of Wave 4 and Wave 5.

Table S3. Intraclass correlation coefficients (ICC) on multimorbidity, health service use and labour participation

	Multimorbidity	Any outpatient visit	Any inpatient visit	10% of total household expenditure	25% of total household expenditure	40% of non-food expenditure	Labour participation
Individual							
Variance (SE)	1.09 (0.25)	0.10 (0.18)	0.57 (0.74)	0 (0)	0 (0)	0 (0)	1.22 (0.30)
ICC (SE)	0.34 (0.03)	0.14 (0.03)	0.25 (0.12)	0.25 (0.03)	0.48 (0.04)	0.69 (0.04)	0.48 (0.03)
Household							
Variance (SE)	0.64 (0.20)	0.43 (0.14)	0.54 (0.57)	1.13 (0.20)	3.08 (0.55)	7.29 (1.3)	1.70 (0.28)
ICC (SE)	0.13 (0.40)	0.11 (0.04)	0.12 (0.12)	0.25 (0.03)	0.48 (0.04)	0.69 (0.04)	0.28 (0.04)
District							
Variance (SE)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.07 (0.04)
ICC (SE)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.01 (0.01)

Note:
All models are controlled for study variables, including sex, age, marital status, education, ethnicity, insurance coverage, type of work, per capita expenditure (PCE), residency, and region. SE: standard error. ICC: intraclass correlation

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Table S4. Robustness check: descriptive summary and factors associated with multimorbidity (cross-sectional analysis of 2014 IFLS)

Characteristics	Weighted % Of sample	Zero NCD (%, 95% CI)	One NCD (%, 95% CI)	Two NCDs (%, 95% CI)	Three or more NCDs (%, 95% CI)	Multimorbidity[b] (%, 95% CI)	Multimorbidity[b] aOR (95% CI)
Sex							
Female	51.9	24.8 (22.3, 26.3)	46.1 (44.4, 47.8)	18.8 (17.5, 20.1)	10.3 (9.3, 11.4)	29.1 (27.6, 30.6)	1
Male	48.1	36.5 (34.7, 38.3)	42.0 (40.2, 43.9)	14.0 (12.8, 15.4)	7.4 (6.5, 8.4)	21.5 (20.0, 23.0)	0.68*** (0.59–0.78)
Age							
50 – 60 years	56.2	35.3 (33.7, 37.1)	41.0 (39.3, 42.7)	15.2 (14.0, 16.5)	8.5 (7.6, 9.5)	23.7 (22.8, 25.2)	1
61 – 70 years	25.6	26.5 (24.4, 28.8)	45.4 (42.9, 47.9)	17.7 (15.9, 19.6)	10.4 (9.0, 11.9)	28.1 (25.6, 30.3)	1.23*** (1.10–1.42)
71+ years	18.2	20.8 (18.6, 23.3)	52.2 (49.4, 55.1)	18.8 (16.7, 21.0)	8.2 (6.8, 9.8)	26.9 (24.6, 29.5)	1.85 (0.99–1.42)
Marital status							
Not currently married	28.2	24.7 (22.7, 26.8)	46.9 (44.6, 49.2)	19.3 (17.5, 21.2)	9.1 (8.0, 10.5)	28.4 (26.4, 30.5)	1
Currently married	71.8	32.7 (31.3, 34.1)	43.1 (41.6, 44.6)	15.4 (14.4, 16.5)	8.8 (8.0, 9.7)	24.2 (23.0, 25.5)	1.05 (0.89–1.21)
Educational level							
No education	53.3	31.3 (29.7, 33.0)	47.7 (45.9, 49.4)	14.1 (13.0, 15.4)	6.9 (6.1, 7.8)	21.0 (19.7, 22.4)	1
Primary	23.8	30.0 (27.6, 32.4)	42.8 (40.2, 45.4)	18.2 (16.3, 20.3)	9.0 (7.7, 10.6)	27.2 (25.0, 29.6)	1.35*** (1.16–1.57)
Junior high school	7.8	30.9 (27.0, 35.1)	34.8 (30.7, 39.1)	20.2 (16.9, 23.9)	14.2 (11.4, 17.5)	34.4 (30.3, 38.6)	1.66*** (1.33–2.06)
Senior high school	10.0	30.4 (26.9, 34.1)	38.7 (35.0, 42.6)	18.0 (15.3, 21.1)	12.8 (10.4, 15.7)	30.9 (27.4, 34.5)	1.23 (0.99–1.53)
Tertiary	5.1	22.8 (18.5, 27.8)	38.7 (33.5, 44.2)	24.4 (20.0, 29.4)	14.1 (10.6, 18.4)	38.4 (33.3, 43.9)	1.77*** (1.33–2.36)
Ethnicity							
Javanese	56.3	31.3 (29.7, 33.0)	45.7 (44.0, 47.5)	15.2 (14.0, 16.5)	7.7 (6.8, 8.6)	22.9 (21.5, 24.4)	1
Sundanese	15.5	22.9 (20.1 25.9)	43.4 (40.0, 46.8)	21.1 (18.4, 24.0)	12. (10.6, 15.1)	33.7 (30.6, 37.0)	1.53*** (1.28–1.83)
Others	28.2	32.7 (30.8, 34.7)	41.5 (39.4, 43.5)	16.5 (15.1, 18.0)	9.3 (8.2, 10.6)	25.8 (24.1, 27.6)	1.04 (0.89–1.22)
Had any health insurance							
No	53.9	32.4 (30.8, 34.1)	46.2 (44.4, 47.9)	14.3 (13.1, 15.5)	7.1 (6.3, 8.1)	21.4 (20.1, 22.9)	1
Yes	46.1	28.1 (26.5, 29.8)	41.8 (40.0, 43.6)	19.0 (17.7, 20.5)	11.0 (9.9, 12.2)	30.0 (28.4, 31.7)	1.22*** (1.23–1.57)
Type of work							
Unemployed	30.6	19.8 (18.1, 21.7)	44.2 (42.0, 46.4)	21.3 (19.6, 23.2)	14.6 (13.2, 16.3)	36.0 (33.9, 38.1)	1
Casual	15.6	36.1 (33.0, 39.4)	45.5 (42.2, 48.7)	13.3 (11.3, 15.7)	5.0 (3.8, 6.6)	18.4 (16.0, 21.0)	0.50*** (0.41–0.62)
Self-employed	39.8	34.6 (32.7, 36.6)	44.4 (42.4, 46.4)	14.5 (13.2, 16.0)	6.4 (5.5, 7.5)	21.0 (19.4, 22.7)	0.57*** (0.49–0.66)
Government/private	14.0	35.2 (32.0, 38.6)	41.9 (38.6, 45.4)	15.0 (12.8, 17.5)	7.8 (6.2, 9.9)	22.8 (20.1, 25.8)	0.50*** (0.40–0.62)
Household expenditure							
Q1 (the lowest)	21.3	33.2 (30.7, 35.9)	49.3 (46.5, 52.1)	12.7 (11.0, 14.6)	4.8 (3.7, 6.1)	17.5 (15.5, 19.6)	1
Q2	20.9	33.5 (30.8, 36.2)	45.0 (42.3, 47.9)	15.6 (13.7, 17.7)	5.8 (4.6, 7.3)	21.5 (19.2, 23.8)	1.28** (1.05–1.58)
Q3	19.8	31.7 (29.1, 34.4)	43.7 (41.0, 46.5)	6.0 (14.0, 18.1)	8.6 (7.2, 10.3)	24.6 (22.2, 17.1)	1.46*** (1.19–1.78)
Q4	19.5	28.8 (26.3, 31.5)	41.5 (38.7, 44.3)	18.8 (16.7, 21.1)	10.9 (9.3, 12.7)	19.7 (27.2, 32.3)	1.80*** (1.47–2.20)
Q5 (the highest)	18.5	24.0 (21.7, 26.5)	40.5 (37.8, 43.3)	19.9 (17.8, 22.2)	15.5 (13.5, 17.6)	35.4 (32.8, 38.1)	2.03*** (1.65–2.50)
Residency							
Rural	48.9	33.3 (31.5, 35.1)	46.4(44.5, 48.3)	14.2 (12.9, 15.5)	6.1 (52.5, 7.0)	20.3 (18.8, 21.8)	1
Urban	51.3	27.7 (26.2, 29.2)	42.0 (40.3, 43.7)	19.0 (17.4, 20.0)	11.6 (10.6, 12.7)	30.3 (28.8, 31.9)	1.37*** (1.19–1.56)
Island							
Java-Bali	78.6	30.3 (28.9, 31.7)	44.7 (43.2, 16.2)	16.0 (15.0, 17.1)	9.0 (8.2, 9.9)	25.1 (23.8, 26.4)	1
Sumatra	14.0	30.6 (28.2, 33.1)	41.1 (38.5, 43.7)	19.1 (17.1, 21.2)	9.2 (7.8, 10.8)	28.3 (26.0, 30.7)	1.34*** (1.14–1.58)
Nusa Tenggara	2.4	37.2 (32.9, 41.7)	47.2 (42.7, 51.7)	13.3 (10.5, 16.6)	2.3 (12.8, 4.1)	15.6 (12.6, 19.1)	0.62*** (0.46–0.83)
Kalimantan	2.4	24.3 (19.7, 29.5)	41.5 (36.1, 47.2)	22.9 (18.6, 27.9)	11.3 (8.2, 15.3)	34.2 (29.1, 39.7)	2.02*** (1.53–2.67)
Sulawesi	2.6	33.6 (28.7, 38.9)	44.7 (39.4, 50.0)	14.2 (10.9, 18.4)	7.5 (5.2, 10.6)	21.7 (17.7, 26.4)	0.87 (0.64–1.18)
Overall Sample	100	30.4 (29.3, 31.6)	44.1 (42.9, 45.4)	16.5 (15.6, 17.4)	8.9 (8.2, 9.6)	25.4 (24.3, 26.5)	

[a] Weighted sample size

[b] We defined multimorbidity if the respondents reported that they had 2 or more chronic conditions related to NCDs. Chronic diseases in IFLS5 included hypertension, diabetes mellitus, asthma, chronic heart diseases, mental health issue, stroke, liver diseases, cancer/malignancies, liver, arthritis, high cholesterol, prostate illness kidney diseases, digestive system diseases.

aOR: adjusted odds ratio

*** p<0.01, ** p<0.05

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Table S5. Robustness check: The effect of multimorbidity on health service use (cross-sectional analysis of 2014 IFLS)

Variables	Health service use			
	Outpatient		Inpatient	
	Any visit	Number of visits	Any visit	Number of visits
	aOR (95% CI)	IRR (95% CI)	aOR (95% CI)	IRR (95% CI)
Number of NCDs (ref. no NCD)				
Single NCD	1.54*** (1.30–1.82)	1.50*** (1.24–1.81)	1.73** (1.17–2.56)	2.03*** (1.36–3.03)
Two NCDs	2.77*** (2.29–3.36)	2.68*** (2.15–3.34)	3.47*** (2.31–5.21)	4.03*** (2.66–6.08)
Three or more NCDs	4.51*** (3.61–5.63)	3.85*** (3.06–4.84)	6.85***(4.45–10.52)	8.78*** (5.73–13.45)
Sex (ref. Male)				
Female	1.26***(1.09–1.45)	1.18**(1.02–1.35)	0.93 (0.72–1.22)	0.81 (0.62–1.07)
Age (ref. 50 – 60 years)				
61 – 70 years	1.01 (0.87–1.18)	0.93 (0.80–1.08)	1.23 (0.91–1.65)	1.23 (0.88–1.72)
71+ years	1.03 (0.85–1.25)	1.01 (0.84–1.21)	1.42 (1.02–2.00)	1.53** (1.01–2.32)
Marital status (ref. Not married)				
Currently married	1.09 (0.93–1.27)	1.04 (0.90–1.21)	1.07 (0.80–1.41)	0.93 (0.70–1.25)
Educational level (ref. No education)				
Primary	0.94 (0.80–1.10)	0.87* (0.74–1.01)	1.02 (0.75–1.39)	0.96 (0.69–1.35)
Junior high school	1.02 (0.80–1.31)	1.07 (0.76–1.52)	0.72 (0.45–1.14)	0.82 (0.47–1.44)
Senior high school	0.87 (0.68–1.10)	0.80* (0.64–1.00)	0.69 (0.44–1.08)	0.63* (0.39–1.00)
Tertiary	0.99 (0.73–1.33)	0.79 (0.55–1.13)	0.58* (0.33–1.02)	0.55* (0.30–1.00)
Ethnicity (ref. Javanese)				
Sundanese	0.93 (0.77–1.13)	0.97 (0.81–1.17)	1.17 (0.84–1.63)	1.21 (0.82–1.79)
Others	1.06 (0.89–1.25)	0.99 (0.84–1.17)	0.78 (0.56–1.08)	0.87 (0.62–1.22)
Insurance coverage (ref. No)				
Yes	1.20*** (1.06–1.37)	1.25*** (1.10–1.44)	2.28*** (1.77–2.95)	2.19*** (1.66–2.89)
Type of work (ref. Unemployed)				
Casual	0.73*** (0.59–0.90)	0.73*** (0.60–0.89)	0.41*** (0.25–0.67)	0.35*** (0.22–0.55)
Self-employed	0.77*** (0.66–0.90)	0.77*** (0.66–0.90)	0.64*** (0.47–0.87)	0.64*** (0.46–0.90)
Government/private	0.70*** (0.56–0.88)	0.75*** (0.60–0.93)	0.43*** (0.28–0.66)	0.53** (0.30–0.94)
Per capita expenditure (ref. Q1)				
Q2	1.36*** (1.10–1.68)	1.40*** (1.14–1.73)	0.86 (0.57–1.31)	0.76 (0.48–1.18)
Q3	1.50*** (1.21–1.85)	1.71*** (1.35–2.17)	1.16 (0.78–1.72)	1.29 (0.80–2.05)
Q4	1.93*** (1.56–2.38)	1.75*** (1.44–2.14)	1.24 (0.83–1.85)	1.35 (0.87–2.08)
Q5	1.87*** (1.50–2.33)	2.02*** (1.63–2.51)	2.06*** (1.38–3.06)	1.98*** (1.32–2.96)
Residency (ref. Rural)				
Urban	0.94 (0.82–1.08)	0.98 (0.86–1.13)	0.93 (0.71–1.21)	1.03 (0.79–1.34)
Region (ref. Java-Bali)				
Sumatra	0.72*** (0.60–0.86)	0.86 (0.72–1.03)	1.32 (0.96–1.82)	1.46** (1.04–2.06)
Nusa Tenggara	0.84 (0.63–1.12)	0.84 (0.63–1.12)	1.83** (1.09–3.06)	1.87** (1.08–3.25)
Kalimantan	0.81 (0.59–1.11)	0.85 (0.62–1.14)	1.46 (0.82–2.58)	1.4 (0.81–2.42)
Sulawesi	0.54*** (0.39–0.75)	0.53*** (0.39–0.71)	1.45 (0.81-2.60)	1.59 (0.85–2.98)

Chronic diseases in IFLS5 included hypertension-diabetes mellitus-asthma-chronic heart diseases-mental health issue-stroke-liver diseases-cancer/malignancies-liver-arthritis-high cholesterol-prostate illness kidney diseases-digestive system diseases.
aOR: adjusted odds ratio, IRR: incidence rate ratio, NCD: noncommunicable disease
*** p<0.01, ** p<0.05

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Table S6. Robustness check: The effect of multimorbidity on catastrophic health expenditure (cross-sectional analysis of 2014 IFLS)

Variables	Catastrophic health expenditure		
	10% of total household expenditure	25% of total household expenditure	40% of non-food expenditure
	aOR (95% CI)	aOR (95% CI)	aOR (95% CI)
Number of NCDs (ref. no NCD)			
Single NCD	1.25 (0.94–1.66)	1.18 (0.67–2.09)	1.58 (0.98–2.57)
Two NCDs	2.03*** (1.48–2.79)	2.10** (1.12–3.93)	2.39*** (1.38–4.14)
Three or more NCDs	2.24*** (1.57–3.20)	2.09** (1.06–4.12)	2.17** (1.18–4.01)
Sex (ref. Male)			
Female	0.87 (0.68–1.12)	0.74 (0.43–1.27)	0.90 (0.59–1.37)
Age (ref. 50 – 60 years)			
61 – 70 years	1.24 (0.96–1.60)	1.34 (0.82–2.20)	1.42 (0.94–2.14)
71+ years	1.32 (0.96–1.81)	1.06 (0.53–2.13)	1.48 (0.88–2.51)
Marital status (ref. Not married)			
Currently married	1.44** (1.08–1.91)	1.69* (0.91–3.17)	1.94*** (1.20–3.14)
Educational level (ref. No education)			
Primary	1.14 (0.88–1.48)	1.31 (0.79–2.17)	1.46 (0.98–2.18)
Junior high school	1.11 (0.76–1.63)	1.28 (0.67–2.46)	1.12 (0.63–1.98)
Senior high school	0.73 (0.49–1.08)	0.52 (0.22–1.23)	0.45** (0.21–0.97)
Tertiary	0.74 (0.43–1.27)	0.22 (0.05–1.01)	0.12** (0.02–0.66)
Ethnicity (ref. Javanese)			
Sundanese	0.87 (0.64–1.18)	1.09 (0.62–1.89)	0.83 (0.51–1.35)
Others	0.79 (0.60–1.04)	0.65 (0.36–1.18)	0.47*** (0.28–0.78)
Insurance coverage (ref. No)			
Yes	1 (0.81–1.25)	1.07 (0.71–1.61)	1.02 (0.72–1.44)
Type of work (ref. Unemployed)			
Casual	0.66** (0.46–0.95)	0.56 (0.27–1.16)	0.56 (0.31–1.04)
Self-employed	0.70*** (0.53–0.91)	0.44*** (0.24–0.79)	0.54*** (0.34–0.85)
Government/private	0.57*** (0.39–0.83)	0.41** (0.19–0.88)	0.46** (0.23–0.91)
Per capita expenditure (ref. Q1)			
Q2	0.96 (0.65–1.43)	1.05 (0.47–2.35)	1.24 (0.67–2.33)
Q3	1.42 (0.99–2.02)	1 (0.46–2.17)	1.08 (0.58–2.01)
Q4	1.59** (1.11–2.27)	2.37** (1.15–4.86)	2.18*** (1.21–3.92)
Q5	2.53*** (1.76–3.62)	2.44** (1.18–5.05)	2.75*** (1.51–5.02)
Residency (ref. Rural)			
Urban	1.01 (0.80–1.26)	0.87 (0.56–1.37)	0.94 (0.65–1.35)
Region (ref. Java-Bali)			
Sumatra	0.94 (0.71–1.24)	0.94 (0.55–1.60)	1.36 (0.88–2.09)
Nusa Tenggara	0.81 (0.48–1.37)	1.49 (0.59–3.76)	1.57 (0.68–3.66)
Kalimantan	1.13 (0.69–1.84)	1.5 (0.59–3.83)	1.56 (0.71–3.47)
Sulawesi	1.02 (0.60–1.73)	0.4 (0.08–2.07)	1.18 (0.45–3.10)

Chronic diseases in IFLS5 included hypertension-diabetes mellitus-asthma-chronic heart diseases-mental health issue-stroke-liver diseases-cancer/malignancies-liver-arthritis-high cholesterol-prostate illness kidney diseases-digestive system diseases.
aOR: adjusted odds ratio, IRR: incidence rate ratio, NCD: noncommunicable disease
*** p<0.01, ** p<0.05

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Table S7. Robustness check: The effect of multimorbidity on productivity loss (cross-sectional analysis of 2014 IFLS)

Variables	Productivity loss		
	Labour participation	Days primary activity missed	Days stayed in bed
	aOR (95% CI)	IRR (95% CI)	IRR (95% CI)
Number of NCDs (ref. no NCD)			
Single NCD	0.76*** (0.65–0.89)	1.48*** (1.29–1.70)	1.32** (1.01–1.72)
Two NCDs	0.54*** (0.45–0.65)	2.42*** (2.09–2.80)	2.18*** (1.60–2.97)
Three or more NCDs	0.32*** (0.26–0.40)	3.29*** (2.79–3.87)	2.80*** (2.02–3.88)
Sex (ref. Male)			
Female	0.31***(0.27–0.35)	1.05 (0.94–1.18)	1.22 (0.97–1.54)
Age (ref. 50 – 60 years)			
61 – 70 years	0.40*** (0.34–0.46)	0.97 (0.86–1.10)	0.93 (0.72–1.21)
71+ years	0.15*** (0.13–0.18)	1.19** (1.03–1.37)	1.78*** (1.33–2.36)
Marital status (ref. Not married)			
Currently married	1.22*** (1.05–1.41)	1.07 (0.95–1.20)	0.93 (0.72–1.21)
Primary	1.08 (0.92–1.26)	1.02 (0.90–1.17)	1.03 (0.81–1.32)
Junior high school	0.64*** (0.51–0.81)	1.02 (0.85–1.22)	1.01 (0.64–1.61)
Senior high school	0.61*** (0.49–0.76)	0.73*** (0.60–0.89)	0.73 (0.46–1.15)
Tertiary	1.09 (0.79–1.48)	0.59*** (0.43–0.83)	0.37*** (0.19–0.71)
Ethnicity (ref. Javanese)			
Sundanese	0.69*** (0.57–0.83)	1.25*** (1.10–1.43)	1.70*** (1.29–2.24)
Others	0.72*** (0.61–0.86)	0.93 (0.81–1.07)	1.34** (1.01–1.77)
Insurance coverage (ref. No)			
Yes	0.91 (0.80–1.04)	1.02 (0.92–1.13)	0.87 (0.71–1.06)
Type of work (ref. Unemployed)			
Casual	n/a	0.51*** (0.43–0.60)	0.28*** (0.20–0.39)
Self-employed		0.55*** (0.49–0.63)	0.33*** (0.26–0.42)
Government/private		0.44*** (0.37–0.54)	0.22*** (0.14–0.33)
Per capita expenditure (ref. Q1)			
Q2	1.25** (1.03–1.52)	1.02 (0.88–1.19)	1.11 (0.82–1.51)
Q3	1.17 (0.96–1.43)	1.12 (0.95–1.32)	0.8 (0.59–1.09)
Q4	0.96 (0.79–1.17)	0.95 (0.81–1.12)	0.89 (0.66–1.21)
Q5	1.07 (0.86–1.32)	1.02 (0.86–1.20)	0.83 (0.61–1.14)
Residency (ref. Rural)			
Urban	0.57*** (0.50–0.65)	1 (0.90–1.12)	0.88 (0.72–1.09)
Region (ref. Java-Bali)			
Sumatra	1.04 (0.87–1.23)	1.12 (0.97–1.29)	1.03 (0.78–1.36)
Nusa Tenggara	1.17 (0.89–1.54)	1.14 (0.92–1.42)	0.91 (0.59–1.40)
Kalimantan	1.42** (1.02–1.99)	1.16 (0.91–1.48)	0.73 (0.48–1.10)
Sulawesi	0.59*** (0.43–0.79)	1.39** (1.07–1.81)	1.05 (0.70–1.59)

Chronic diseases in IFLS5 included hypertension-diabetes mellitus-asthma-chronic heart diseases-mental health issue-stroke-liver diseases-cancer/malignancies-liver-arthritis-high cholesterol-prostate illness kidney diseases-digestive system diseases.
aOR: adjusted odds ratio, IRR: incidence rate ratio, NCD: noncommunicable disease
*** p<0.01, ** p<0.05

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Table S8. Sensitivity analysis: the effect of multimorbidity on health service use

Obesity (BMI ≥25 kg/m2 as obese) is included in the clustering of multimorbidity

Variables	Health service use							
	Outpatient				Inpatient			
	Any visit[a)]		Number of visits[b)]		Any visit[a)]		Number of visits[b)]	
	aOR (95% CI)	p values	IRR (95% CI)	p values	aOR (95% CI)	p values	IRR (95% CI)	p values
Number of NCDs (ref. no NCD)								
Single NCD	1.18 (0.98–1.43)	0.086	1.24 (1.04–1.50)	0.020	1.16 (0.79–1.70)	0.451	1.16 (0.79–1.70)	0.488
Two NCDs	1.82 (1.47–2.25)	0.000	1.83 (1.50–2.25)	0.000	1.78 (1.18–2.69)	0.006	1.78 (1.18–2.69)	0.002
Three or more NCDs	3.27 (2.55–4.19)	0.000	2.85 (2.26–3.60)	0.000	2.73 (1.76–4.25)	0.000	2.73 (1.76–4.25)	0.000
Period (ref.2007)								
2014	1.33 (1.15–1.53)	0.000	1.29 (1.12–1.49)	0.000	1.72 (1.29–2.29)	0.000	1.72 (1.29–2.29)	0.000
Sex (ref. Male)								
Female	1.19 (1.00–1.41)	0.049	1.13 (0.96–1.33)	0.139	0.91 (0.67–1.24)	0.537	0.91 (0.67–1.24)	0.413
Age (ref. 50 – 60 years)								
61 – 70 years	1.06 (0.90–1.26)	0.475	1.05 (0.89–1.23)	0.588	1.09 (0.79–1.50)	0.603	1.09 (0.79–1.50)	0.332
71+ years	1.20 (0.96–1.50)	0.109	1.15 (0.93–1.41)	0.187	1.58 (1.07–2.33)	0.020	1.58 (1.07–2.33)	0.020
Marital status (ref. Not married)								
Currently married	1.09 (0.92–1.31)	0.323	1.15 (0.97–1.36)	0.105	1.05 (0.77–1.44)	0.742	1.05 (0.77–1.44)	0.962
Educational level (ref. No education)								
Primary	1.06 (0.88–1.27)	0.556	0.97 (0.82–1.16)	0.760	1.09 (0.78–1.51)	0.630	1.09 (0.78–1.51)	0.796
Junior high school	1.04 (0.78–1.40)	0.777	1.11 (0.85–1.46)	0.441	1.18 (0.73–1.92)	0.498	1.18 (0.73–1.92)	0.105
Senior high school	1.01 (0.76–1.35)	0.954	0.94 (0.72–1.23)	0.636	0.78 (0.47–1.29)	0.335	0.78 (0.47–1.29)	0.147
Tertiary	1.18 (0.79–1.76)	0.427	0.84 (0.57–1.23)	0.371	0.94 (0.50–1.78)	0.858	0.94 (0.50–1.78)	0.495
Ethnicity (ref. Javanese)								
Sundanese	0.91 (0.72–1.16)	0.456	0.92 (0.74–1.15)	0.486	0.90 (0.59–1.37)	0.628	0.90 (0.59–1.37)	0.944
Others	1.02 (0.85–1.24)	0.802	0.92 (0.77–1.09)	0.313	0.91 (0.65–1.28)	0.603	0.91 (0.65–1.28)	0.557
Insurance coverage (ref. No)								
Yes	1.48 (1.27–1.73)	0.000	1.57 (1.36–1.81)	0.000	2.02 (1.52–2.69)	0.000	2.02 (1.52–2.69)	0.000
Type of work (ref. Unemployed)								
Casual	0.77 (0.61–0.97)	0.025	0.66 (0.53–0.82)	0.000	0.48 (0.30–0.79)	0.003	0.48 (0.30–0.79)	0.001
Self-employed	0.83 (0.70–0.99)	0.041	0.76 (0.64–0.89)	0.001	0.60 (0.43–0.83)	0.002	0.60 (0.43–0.83)	0.001
Government/private	0.74 (0.56–0.98)	0.034	0.67 (0.52–0.88)	0.004	0.61 (0.36–1.02)	0.061	0.61 (0.36–1.02)	0.242
Per capita household expenditure (ref. Q1)								
Q2	1.48 (1.17–1.86)	0.001	1.50 (1.20–1.87)	0.000	1.26 (0.80–2.01)	0.322	1.26 (0.80–2.01)	0.500
Q3	1.71 (1.35–2.15)	0.000	1.74 (1.39–2.17)	0.000	1.77 (1.14–2.76)	0.012	1.77 (1.14–2.76)	0.003
Q4	1.70 (1.34–2.16)	0.000	1.77 (1.41–2.22)	0.000	1.44 (0.90–2.31)	0.131	1.44 (0.90–2.31)	0.092
Q5	1.79 (1.39–2.31)	0.000	1.98 (1.56–2.51)	0.000	2.67 (1.68–4.26)	0.000	2.67 (1.68–4.26)	0.000
Residency (ref. Rural)								
Urban	0.87 (0.74–1.02)	0.093	0.92 (0.79–1.07)	0.258	0.96 (0.72–1.28)	0.775	0.96 (0.72–1.28)	0.689
Region (ref. Java-Bali)								
Sumatra	0.83 (0.67–1.03)	0.094	1.03 (0.85–1.26)	0.736	1.21 (0.84–1.75)	0.294	1.21 (0.84–1.75)	0.322
Nusa Tenggara	0.69 (0.48–0.99)	0.043	0.62 (0.44–0.87)	0.006	1.24 (0.69–2.22)	0.467	1.24 (0.69–2.22)	0.707
Kalimantan	1.04 (0.71–1.50)	0.851	1.31 (0.94–1.83)	0.115	0.99 (0.50–1.97)	0.982	0.99 (0.50–1.97)	0.764
Sulawesi	0.72 (0.48–1.07)	0.107	0.68 (0.47–0.99)	0.043	0.52 (0.22–1.22)	0.134	0.52 (0.22–1.22)	0.055

[a)] Multilevel logistic regression model

[b)] Multilevel negative binomial regression model

Obesity (BMI ≥25 kg/m2 as obese) is included in the clustering of multimorbidity

aOR: adjusted odds ratio, IRR: Incidence rate ratio, NCD: noncommunicable disease

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Table S9. Sensitivity analysis: the effect of multimorbidity on catastrophic expenditure

Obesity (BMI ≥25 kg/m2 as obese) is included in the clustering of multimorbidity

Variables	Catastrophic health expenditure					
	10% of total household expenditure[a)]		25% of total household expenditure[a)]		40% of non-food expenditur [a)]	
	aOR (95% CI)	p values	aOR (95% CI)	p values	aOR (95% CI)	p values
Number of NCDs (ref. no NCD)						
Single NCD	1.12 (0.84–1.51)	0.434	0.89 (0.54–1.47)	0.642	0.93 (0.62–1.41)	0.743
Two NCDs	1.23 (0.88–1.72)	0.235	1.27 (0.74–2.17)	0.382	1.22 (0.77–1.91)	0.396
Three or more NCDs	1.66 (1.12–2.45)	0.011	0.99 (0.50–1.94)	0.976	1.08 (0.63–1.88)	0.773
Period (ref.2007)						
2014	1.37 (1.09–1.74)	0.008	1.21 (0.81–1.81)	0.351	1.16 (0.84–1.62)	0.367
Sex (ref. Male)						
Female	0.92 (0.72–1.19)	0.528	1.00 (0.64–1.54)	0.991	1.01 (0.70–1.45)	0.949
Age (ref. 50 – 60 years)						
61 – 70 years	1.18 (0.91–1.53)	0.207	1.47 (0.95–2.29)	0.085	1.49 (1.03–2.16)	0.033
71+ years	1.08 (0.77–1.53)	0.651	0.87 (0.45–1.67)	0.672	1.37 (0.83–2.25)	0.218
Marital status (ref. Not married)						
Currently married	1.54 (1.15–2.05)	0.003	1.66 (1.01–2.71)	0.044	1.82 (1.21–2.72)	0.004
Educational level (ref. No education)						
Primary	0.93 (0.70–1.23)	0.607	0.87 (0.53–1.44)	0.596	0.88 (0.59–1.31)	0.530
Junior high school	0.88 (0.57–1.35)	0.555	1.04 (0.51–2.09)	0.921	0.67 (0.35–1.28)	0.227
Senior high school	0.85 (0.55–1.29)	0.442	1.05 (0.53–2.07)	0.885	0.82 (0.45–1.47)	0.500
Tertiary	0.39 (0.18–0.84)	0.016	0.13 (0.02–0.96)	0.045	0.18 (0.04–0.75)	0.018
Ethnicity (ref. Javanese)						
Sundanese	0.83 (0.57–1.21)	0.339	1.64 (0.91–2.95)	0.099	1.17 (0.71–1.94)	0.529
Others	0.75 (0.56–1.02)	0.069	0.96 (0.57–1.60)	0.872	0.72 (0.47–1.10)	0.129
Insurance coverage (ref. No)						
Yes	0.94 (0.74–1.20)	0.613	0.83 (0.54–1.27)	0.388	0.80 (0.56–1.15)	0.227
Type of work (ref. Unemployed)						
Casual	0.62 (0.42–0.91)	0.016	0.59 (0.31–1.14)	0.116	0.56 (0.33–0.95)	0.032
Self-employed	0.64 (0.47–0.87)	0.005	0.65 (0.41–1.03)	0.068	0.66 (0.45–0.97)	0.033
Government/private	0.61 (0.38–0.97)	0.038	0.77 (0.37–1.61)	0.488	0.63 (0.33–1.22)	0.169
Per capita household expenditure (ref. Q1)						
Q2	1.11 (0.74–1.65)	0.619	1.40 (0.66–2.94)	0.379	1.54 (0.85–2.77)	0.151
Q3	1.46 (0.99–2.15)	0.058	1.74 (0.85–3.58)	0.130	1.67 (0.93–2.99)	0.086
Q4	2.01 (1.34–3.01)	0.001	2.58 (1.27–5.26)	0.009	2.42 (1.36–4.31)	0.003
Q5	3.27 (2.10–5.11)	0.000	4.64 (2.29–9.38)	0.000	4.71 (2.66–8.34)	0.000
Residency (ref. Rural)						
Urban	0.99 (0.74–1.31)	0.936	0.85 (0.52–1.40)	0.526	0.88 (0.59–1.32)	0.550
Region (ref. Java-Bali)						
Sumatra	0.82 (0.58–1.16)	0.257	0.78 (0.43–1.41)	0.411	1.12 (0.70–1.78)	0.633
Nusa Tenggara	0.70 (0.37–1.35)	0.287	1.22 (0.39–3.77)	0.730	0.87 (0.33–2.29)	0.772
Kalimantan	0.86 (0.46–1.59)	0.632	0.77 (0.26–2.30)	0.637	0.96 (0.40–2.26)	0.918
Sulawesi	0.83 (0.43–1.61)	0.584	1.00 (0.36–2.79)	0.994	1.08 (0.44–2.63)	0.864

[a)] Multilevel logistic regression model

Obesity (BMI ≥25 kg/m2 as obese) is included in the clustering of multimorbidity

aOR: adjusted odds ratio, NCD: noncommunicable disease

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Table S10. Sensitivity analysis: the effect of multimorbidity on productivity loss

Obesity (BMI ≥25 kg/m2 as obese) is included in the clustering of multimorbidity

Variables	Productivity loss					
	Labour participation[a)]		Days primary activity missed[b)]		Days stayed in bed[b)]	
	aOR (95% CI)	p values	IRR (95% CI)	p values	IRR (95% CI)	p values
Number of NCDs (ref. no NCD)						
Single NCD	0.66 (0.54–0.82)	0.000	1.16 (0.99–1.36)	0.063	1.10 (0.82–1.48)	0.533
Two NCDs	0.45 (0.35–0.58)	0.000	1.70 (1.41–2.04)	0.000	1.37 (0.98–1.92)	0.065
Three or more NCDs	0.37 (0.27–0.49)	0.000	2.21 (1.76–2.76)	0.000	2.16 (1.44–3.25)	0.000
Period (ref. 2007)						
2014	0.76 (0.65–0.89)	0.001	1.54 (1.35–1.75)	0.000	1.44 (1.13–1.85)	0.004
Sex (ref. Male)						
Female	0.22 (0.17–0.27)	0.000	0.96 (0.83–1.11)	0.555	0.90 (0.68–1.20)	0.480
Age (ref. 50 – 60 years)						
61 – 70 years	0.36 (0.29–0.44)	0.000	1.02 (0.89–1.18)	0.758	1.15 (0.87–1.52)	0.336
71+ years	0.10 (0.08–0.13)	0.000	1.17 (0.97–1.41)	0.094	1.77 (1.24–2.52)	0.002
Marital status (ref. Not married)						
Currently married	1.49 (1.22–1.82)	<0.0001	1.18 (1.01–1.37)	0.032	0.96 (0.72–1.29)	0.809
Educational level (ref. No education)						
Primary	0.90 (0.72–1.13)	0.372	0.92 (0.79–1.07)	0.269	1.03 (0.77–1.38)	0.851
Junior high school	0.41 (0.29–0.58)	<0.0001	0.91 (0.71–1.16)	0.438	0.68 (0.42–1.10)	0.118
Senior high school	0.43 (0.30–0.61)	<0.0001	0.64 (0.50–0.83)	0.001	0.65 (0.40–1.04)	0.073
Tertiary	0.56 (0.34–0.92)	0.021	0.52 (0.36–0.75)	<0.0001	0.42 (0.20–0.88)	0.022
Ethnicity (ref. Javanese)						
Sundanese	0.48 (0.36–0.65)	<0.0001	1.39 (1.14–1.70)	0.001	1.51 (1.03–2.21)	0.035
Others	0.80 (0.63–1.01)	0.059	1.13 (0.97–1.33)	0.123	1.13 (0.84–1.53)	0.425
Insurance coverage (ref. No)						
Yes	0.82 (0.69–0.98)	0.032	1.13 (0.99–1.29)	0.077	1.13 (0.88–1.46)	0.329
Type of work (ref. Unemployed)						
Casual	N/A	N/A	0.69 (0.57–0.84)	<0.0001	0.41 (0.28–0.60)	<0.0001
Self-employed	N/A	N/A	0.68 (0.58–0.79)	<0.0001	0.51 (0.38–0.69)	<0.0001
Government/private	N/A	N/A	0.60 (0.47–0.76)	<0.0001	0.56 (0.35–0.90)	0.017
Per capita household expenditure (ref. Q1)						
Q2	1.36 (1.06–1.75)	0.016	1.03 (0.85–1.24)	0.769	0.97 (0.68–1.38)	0.848
Q3	1.27 (0.98–1.64)	0.071	1.17 (0.97–1.42)	0.095	1.11 (0.78–1.59)	0.557
Q4	1.13 (0.86–1.47)	0.383	1.05 (0.86–1.29)	0.602	0.99 (0.68–1.43)	0.944
Q5	1.35 (1.01–1.80)	0.043	1.26 (1.02–1.55)	0.032	0.89 (0.60–1.33)	0.577
Residency (ref. Rural)						
Urban	0.42 (0.34–0.52)	<0.0001	0.92 (0.80–1.06)	0.239	0.69 (0.52–0.90)	0.006
Region (ref. Java-Bali)						
Sumatra	0.91 (0.70–1.20)	0.519	1.14 (0.95–1.38)	0.162	1.10 (0.78–1.55)	0.573
Nusa Tenggara	0.68 (0.44–1.04)	0.077	0.86 (0.64–1.15)	0.309	1.15 (0.66–2.00)	0.629
Kalimantan	1.22 (0.75–1.99)	0.418	0.86 (0.63–1.17)	0.329	0.92 (0.51–1.67)	0.794
Sulawesi	0.34 (0.21–0.55)	<0.0001	1.05 (0.76–1.46)	0.754	1.07 (0.58–1.98)	0.826

[a)] Multilevel logistic regression model

[b)] Multilevel negative binomial regression model

aOR: adjusted odds ratio, IRR: incidence rate ratio, NCD: noncommunicable disease

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STROBE Statement

	Item	Recommendation	Reported on page	Relevant text from manuscript
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1	"Panel Data Analysis"
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2	"Multimorbidity is associated with substantial direct and indirect costs to individuals, households, and the wider society."
Introduction				
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	6	"Evidence from high-income countries (HICs) has found that…"
Objectives	3	State specific objectives, including any prespecified hypotheses	6	"to examine NCD multimorbidity levels, and their relation to households' socioeconomic characteristics, health service use, catastrophic health expenditures, and productivity loss."
Methods				
Study design	4	Present key elements of study design early in the paper	7	"We utilised panel data from two waves of the Indonesian Family Life Survey (IFLS)."
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	7	"Waves 5 was conducted between September 2014–March 2015."
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	7	"This study included respondents aged 50 years and above in 2007 who participated in both Waves 4 and 5, and excluded those with missing values for the study variable."
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	7–8	In "variables" subsection.
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	7–8	In "variables" subsection. Details of the measurements are available in Table S1

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	Item	Recommendation	Reported on page	Relevant text from manuscript
Bias	9	Describe any efforts to address potential sources of bias	11	"Taking into account the hierarchical (nested) nature of the dataset (i.e. observations nested within individuals, and individuals nested within households, and districts), a multilevel level model approach was used."
Study size	10	Explain how the study size was arrived at	7	Our final sample is 3,678 respondents (the sample flowchart is presented in Figure S1).
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	7	In "variables" subsection, i.e. "A total of 10 NCDs were used to quantify the number of NCDs (0, 1, 2, 3 or more) and respondents with two or more NCDs were categorised as having multimorbidity (categorised as 0 or 1)"
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	11	In "statistical analysis" subsection. For example "…, adjusting for covariates"
		(*b*) Describe any methods used to examine subgroups and interactions	11	"We described the patterns of multimorbidity across different population subgroups…"
		(*c*) Explain how missing data were addressed	7	"…excluded those who did not participate in both Waves 4 and 5, and those with missing values for the study"
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy	11	"The results of the descriptive analysis were presented as numbers and weighted percentages with their 95% confidence interval (CI). …"
		(*e*) Describe any sensitivity analyses	11	"We conducted two robustness analyses."
Results				
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	1 (supplementary file)	Figure S1: Sampling flow chart

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	Item	Recommendation	Reported on page	Relevant text from manuscript
		(b) Give reasons for non-participation at each stage	1 (supplementary file)	Figure S1: Sampling flow chart
		(c) Consider use of a flow diagram	1 (supplementary file)	Figure S1: Sampling flow chart
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	1 (supplementary file)	Figure S1: Sampling flow chart
		(b) Indicate number of participants with missing data for each variable of interest	1 (supplementary file)	Figure S1: Sampling flow chart
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)		N/A
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time		N/A
		Case-control study—Report numbers in each exposure category, or summary measures of exposure		N/A
		Cross-sectional study—Report numbers of outcome events or summary measures	25–26	Table 1 and Table 2
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	18–21	Table 2 – Table 5. For example, "Respondents with a single NCD were 1.61 times more likely (95% CI 1.21–2.14) to have experienced an outpatient visit in the past four weeks compared to those without an NCD."
		(*b*) Report category boundaries when continuous variables were categorised	2 (supplementary file)	Table S1: List of variables for 2007 and 2014 IFLS analyses
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period		N/A
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	6–12 (supplementary file)	Tables S6–10. For example, "Our robustness analysis using cross-sectional analysis using 2014 cross-sectional dataset that consists of 14 physical NCDs (Tables S6–10) showed consistent results"
Discussion				

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	Item	Recommendation	Reported on page	Relevant text from manuscript
Key results	18	Summarise key results with reference to study objectives	15	"Multimorbidity was associated with significantly higher use of healthcare services, higher probability of catastrophic health expenditure, and a significant reduction in productivity."
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	18	"There are several limitations to our study."
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	18	"Our findings should be interpreted with caution since the assessment of chronic diseases was mostly based on self-reporting"
Generalisability	21	Discuss the generalisability (external validity) of the study results	19	"This research intentionally focused on the older population due to a significantly higher burden of NCDs in this population group."
Other information				
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	20	Funding This research received no specific grant from any funding agency in the public, commercial or not-for-profit sectors.

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Impact of noncommunicable disease multimorbidity on health service use, catastrophic health expenditure, and productivity loss in Indonesia: a population-based panel data analysis study

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Impact of noncommunicable disease multimorbidity on health service use, catastrophic health expenditure, and productivity loss in Indonesia: a population-based panel data analysis study

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Abstract

Objectives To examine noncommunicable diseases (NCDs) multimorbidity level and its relation to households' socioeconomic characteristics, health service use, catastrophic health expenditures, and productivity loss.

Design This study utilised panel data of the Indonesian Family Life Survey (IFLS) conducted in 2007 (Wave 4) and 2014 (Wave 5).

Setting The original sampling frame was based on 13 out of 27 provinces in 1993, representing 83% of the Indonesian population.

Participants We included respondents aged 50 years and above in 2007, excluding those who did not participate in both Waves 4 and 5. The total number of participants in this study are 3,678 respondents.

Primary outcome measures We examined three main outcomes; health service use (outpatient and inpatient care), financial burden (catastrophic health expenditure), and productivity loss (labour participation, days primary activity missed, days confined in bed). We applied multilevel mixed-effects regression models to assess the associations between NCD multimorbidity and outcome variables,

Results Women were more likely to have NCD multimorbidity than men and the prevalence of NCD multimorbidity increased with higher socioeconomic status. NCD multimorbidity was associated with a higher number of outpatient visits (compared with those without NCD, incidence rate ratio [IRR] 4.25, 95% CI 3.33–5.42 for

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individuals with >3 NCDs) and inpatient visits (IRR 3.68, 95% CI 2.21–6.12 for individuals with >3 NCDs). NCD multimorbidity was also associated with a greater likelihood of experiencing catastrophic health expenditure (for >3 NCDs, adjusted odds ratio [aOR] 1.69, 95% CI 1.02–2.81) and lower participation in the labour force (aOR 0.23, 95% CI 0.16–0.33) compared with no NCD.

Conclusions NCD multimorbidity is associated with substantial direct and indirect costs to individuals, households, and the wider society. Our study highlights the importance of preparing health systems for addressing the burden of multimorbidity in LMICs.

Keywords Multimorbidity, Indonesia, noncommunicable diseases, health service use, catastrophic health expenditure, productivity loss.

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Strengths and limitations of this study

- To our knowledge, our study provides the first comprehensive analysis using the single largest longitudinal survey in Indonesia, which examined the impact of multimorbidity on health service use, catastrophic health expenditure, and productivity loss.
- This study applied multilevel mixed-effects regression models to examine factors associated with multimorbidity and its relationship to the outcome variables, while taking into account the hierarchical (nested) nature of the dataset.
- Our findings should be interpreted with caution since the assessment of NCDs was mostly based on self-reporting, which may not capture the true prevalence rate.
- Despite the fifth waves of IFLS dataset was conducted between 2014 and 2015, the longitudinal design of the survey is extremely useful for measuring the impact of chronic diseases, accounting for within-individual variations over-time.

Introduction

Noncommunicable diseases (NCDs) continue to be the leading cause of global burden of diseases, with 78% of NCD-related mortality concentrated in low-income and middle-income countries (LMICs).[1] The current COVID-19 pandemic highlights that the presence of NCDs can increase the fatality risk of a communicable disease.[2] Indonesia, the third most populous country among LMICs (after China and India) with a population of 273 million, has seen rapid demographic and epidemiological transitions over the last few decades. The threat of NCDs is expected to rise with the aging population (population aged 65 or above), which is projected to account for a quarter of the population by 2070.[3] Concurrently, the prevalence of NCD multimorbidity, defined as the presence of two or more NCDs, is expected to rise rapidly in many LMICs, as both life expectancy and exposure to risk factors increase.[4] Indonesia has started recognising the burden of NCDs due to its substantial contribution to the top causes of death and disability-adjusted life years (DALYs).[5] However, current Indonesia health programs remain limited to curative services, focusing on single

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chronic disease as opposed to assessing and mitigating the impact of multimorbidity on the individual, health system, and wider society.

COVID-19 pandemic emphasises the importance of health systems responsiveness to multimorbidity. Historically, the growing burden of multimorbidity in LMICs was highlighted in the United Nations High-Level Meetings on NCDs in 2011, 2014, and 2018.[6] LMICs typically have low levels of government expenditure for health and inadequate health insurance coverage, which often results in higher levels of out-of-pocket expenditure (OOPE) and risk of impoverishing patients with chronic health conditions.[7,8] The economic burden of multimorbidity is further compounded by the fact that multiple healthcare specialists typically manage multimorbid patients in LMICs.[9] This leads to inefficiencies with numerous different hospital visits, polypharmacy, and suboptimal disease management.[9,10]

While the Indonesian health system is mainly funded by the government, it only spends around 2% of its GDP on health, which is significantly lower than other LMICs with comparable income level.[11] Approximately half of all health spending is covered by the public sector and one-third comes from OOP payment.[12] While the primary health care (PHC) centres are designed as gatekeepers for primary prevention for NCDs, studies have found limited capacity of PHC in proper management of NCDs.[13–15] There is also high public funding allocations to curative services at the hospital-level,[16] with limited investment in preventive and promotive health services.[12] Further, the poor and those living in limited-resource regions have generally lower hospital utilisation due to geographical barriers and high transportation costs.[17,18] Low overall government health

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spending, coupled with limited investment in PHC and the high burden of NCDs may further increase the high OOPE in Indonesia and inequitable access to care.[5]

The Indonesian national health insurance program expansion in 2014 was designed to achieve universal coverage by 2019.[19] However, as of August 2020, the insurance coverage was only at 85.5%,[20] leaving around 40 million people remained uncovered. Furthermore, the insurance program has been in funding deficit since its inception and recent studies identified that it may not be financially sustainable.[1,2] Further, NCDs were responsible for around 60% of total spending of the insurance program. Therefore, addressing NCDs through preventive and promotive programs is pertinent to strengthen the Indonesian health system and the sustainability of its health insurance program.

Evidence from high-income countries (HICs) has found that apart from the negative impact on health outcomes, multimorbidity imposes substantial economic costs on individuals and households. This is because patients with multimorbidity incur large medical expenditures and are more likely to be absent from work.[8,21,22] However, there is no previous study in Indonesia that has examined the economic burden of NCD multimorbidity, as earlier studies have focused on the burden of a single NCD.[23] Results from this study may inform health systems reform across the region and be applicable to similar LMICs. We present the first study that uses longitudinal data to examine NCD multimorbidity levels, and their relationship to households' socioeconomic characteristics, health service use, catastrophic health expenditures, and productivity loss.

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Methods

Sample and data

We utilised panel data from two waves of the Indonesian Family Life Survey (IFLS) conducted in 2007 (Wave 4) and 2014 (Wave 5). IFLS is an ongoing longitudinal survey that started in 1993 with four subsequent rounds of data collection (1997/1998, 2000, 2007/2008, and 2014/2015). The original sample was based on 13 out of 27 provinces in 1993, representing 83% of the population. Wave 5 was conducted between September 2014–March 2015, with 76% re-contact rate from the main respondents of Wave 1. The dataset contains information at the individual- and household-level, including sociodemographic characteristics, healthcare utilisation and expenditure, and labour participation. The objectives and methods of the IFLS are detailed elsewhere.[24,25] This study included respondents aged 50 years and above in 2007 who participated in both Waves 4 and 5, and excluded those with missing values for the study variable. Our final sample is 3,678 respondents and a sample flowchart is presented in Figure S1.

Variables

Multimorbidity

Our main variable of interest was NCD multimorbidity. Fourteen types of NCDs were included in Wave 5, but only 10 NCDs in Wave 4. For consistency, our main analysis used 10 NCDs that were available in both waves, as the following: hypertension, diabetes, asthma, heart attack/coronary heart diseases, liver disease, stroke, cancer, arthritis/rheumatism, hypercholesterolemia, and depression/mental illness. The four NCDs that were only included in Wave 5 were: prostate diseases, kidney diseases (excluding malignancy), digestive diseases, and memory-related diseases.

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NCD status was either identified through self-reporting or physical examination. In the self-report section, respondents who answered affirmatively to the question, "Has a doctor/paramedic/nurse/midwife ever told you that you had any of these conditions?", were defined as reporting an NCD. For hypertension and hypercholesterolemia, the diagnoses were confirmed through a physical examination conducted by trained nurses, i.e. blood pressure and total cholesterol levels. All IFLS respondents aged 15 years and older had their blood pressure recorded three times on alternate arms using Omron self-inflating sphygmomanometers by trained nurses.[24,25] In our analysis, a respondent was categorised as having hypertension if the mean measurement of systolic blood pressure was 140 mm Hg and/or mean diastolic blood pressure was 90 mm Hg or the respondent self-reported having been diagnosed with hypertension.[26] We also included hypercholesterolemia, defined as total blood cholesterol value 240 mg/dl, as morbidity.[27] It is important to note that different measurements of hypercholesterolemia were used in Wave 4 and 5. Blood test for total cholesterol was performed in Wave 4 as opposed to self-reporting of hypercholesterolemia in Wave 5.

A total of 10 NCDs were used to quantify the number of NCDs (0, 1, 2, 3 or more) and respondents with two or more NCDs were categorised as having multimorbidity (0 or 1). Previous studies have typically considered hypertension, obesity, and hypercholesterolemia as risk factors of NCDs and their inclusion in the multimorbidity clustering remains inconsistent.[23,28] Therefore, in the sensitivity analysis, we included obesity, defined as having BMI $\geq$25 kg/m^2, in the clustering of multimorbidity.[29] All statistical analyses were conducted using STATA 13.0.

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Outcome variables

The three main outcomes are: health service use and financial burden as the direct cost and productivity loss as the indirect cost of multimorbidity. Respondents were asked about the number of outpatient visits (in the last four weeks) and inpatient visits (in the last 12 months) and OOPE. The data on OOPE was also collected with four weeks and 12 months recall period for outpatient and inpatient visits, respectively. We calculated the total annual OOPE by multiplying OOPE for outpatient visits with 13 (as the reference period of outpatient expenditure in the IFLS is four weeks and a year consists of 52 weeks), and added OOPE for inpatient visits. The total OOPE reflects all costs associated with outpatient or inpatient visits, including medication, medical consultation, and laboratory tests.

Catastrophic health expenditure occurs when OOPE exceeds certain thresholds of a household's expenditure. The thresholds used in this study were 10% and 25% of total household expenditure (as proposed by the Sustainable Development Goal 3 targets), and the WHO's recommendation at 40% of household's capacity to pay. Capacity to pay is defined as the household's ability to pay for other expenses, including medical costs, after having household subsistence needs met.[30] Household subsistence needs are proxied by the household non-food expenditure variable. Catastrophic health expenditure ($cata_h$) occurrence is expressed as follows:

$$cata_h = 1 \; if \; \frac{HS_h}{THE_h} or \; \frac{HS_h}{CTP_h} > z, \text{ and otherwise is zero.}$$

Where $HS_h$is the total OOPE for health, THE_h is the total household expenditure, CTP_h is capacity to pay, and z is the threshold of capacity to pay. In using the proportion of total OOPE for health to total household expenditure (THE), the threshold z was set at 10% and 25%. Further, in using the proportion of OOPE for health to capacity to pay

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(CTP), the threshold *z* was set at 40%. All monetary values were adjusted for inflation and converted to 2014 International Dollars.[31]

Productivity loss was assessed based on: (1) labour participation; (2) the number of days of primary activity missed due to poor health; and (3) number of days confined to bed. Labour participation status was defined as the respondent's employment status at the time of the survey. The number of days of primary daily activity missed and days confined to bed were included in the health conditions section of the survey, with a four week recall period.

Covariates

Sociodemographic factors included were: sex, age groups (50-60, 61-70, above 70 years), marital status (currently and not currently married), education (no education, primary, junior high school, senior high school, tertiary), ethnicity (Javanese, Sundanese, others), coverage of health insurance (no, yes), type of work (unemployed, casual, self-employed, government/private), and respondents' economic status (per capita expenditure for consumption). The economic status was categorised into quintiles: q1 (lowest) to q5 (highest). We also included residency (rural, urban), region of residency (Java-Bali, Sumatra, Nusa Tenggara, Kalimantan, Sulawesi), and period (using wave 2007 as the reference group) as covariates. Detailed definitions and categorisations are available in Table S1. It should be noted that IFLS did not include the eastern regions which are considered to be underdeveloped.

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Statistical analysis

We described the patterns of multimorbidity across different population subgroups and presented the weighted percentages with 95% confidence interval (CI). Taking into account the hierarchical (nested) nature of the dataset (i.e. observations nested within individuals, and individuals nested within households, and districts),[32] a multilevel level model approach was used to examine factors associated with multimorbidity and its relation to the outcome variables. Multilevel negative binomial regression models were performed to examine the association between multimorbidity and the numbers of outpatient visits and days in the hospital. We used negative binomial models instead of Poisson models due to the over-dispersion of the count data variable. We applied multilevel logistic regression models to observe binary outcome variables and calculated the intra-class correlation coefficients (ICC). The multilevel analyses were conducted using unweighted data, since rather than deriving nationally representative estimates, our aim was on testing the association between multimorbidity and the outcomes and examine the mixed effects.[33] We conducted a robustness check to investigate the association between multimorbidity and costs using the 2014 cross-sectional dataset, that contains information for four additional NCDs than the 2007 IFLS.

Patient and public involvement

Neither patients nor the public were involved in this secondary data analysis.

Results

Descriptive statistics

Table 1 and Table S2 presents the respondents' characteristics by multimorbidity status in 2007 and 2014. The median age in 2007 was 58 years (IQR 54–65), 53.9% were

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female, 74.4% were married, 16.5% had at least secondary education level or above and only 25.5% had health insurance coverage. In 2014, the median age was 65 years (IQR 60–72), and health insurance coverage increased to 42.8%.

A similar prevalence of NCD multimorbidity was observed between 2007 (21.0%, 95% CI 19.6-22.6) and 2014 (22.0%, 95% CI 20.6–23.6). The prevalence of multimorbidity increased with rising socioeconomic status. For example, in 2014, the prevalence increased from 18.0% (95% CI 16.9–20.7) to 41.2% (95% CI 31.6–51.6) between respondents with no education and those with tertiary education. Similarly, the prevalence increased from 13.5% (95% CI 11.1–16.2) to 36.2% (95% CI 32.2–40.5) between the lowest and highest wealth quintiles. The trend of increasing multimorbidity was observed for all age groups, shown in Figure 1, where the fifth and fourth wealth quintiles had a higher prevalence of NCD multimorbidity than the lower quintiles. The prevalence of multimorbidity by level of education is available in Figure S2.

The regression results show that NCD multimorbidity was more likely among those with higher socioeconomic status (Table 1). Respondents in the highest wealth quintile were more likely to report NCD multimorbidity, compared with those in the lowest quintile (aOR 2.22, 95% CI 1.72–2.86). Compared with those with lower educational attainment, respondents with higher educational attainment were more likely to experience NCD multimorbidity (aOR 1.54, 95% CI 1.01–2.34 for tertiary level completed). Additionally, the prevalence of multimorbidity was higher in females than males (aOR 1.74, 95% CI 1.46–2.08) and those living in urban areas (aOR 1.41, 95% CI 1.19–1.67). The ICC shows that above 53% (1-[0.34+0.13]) of the variance can be ascribed to between-individual level differences (Table S3).

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Multimorbidity and health service use

The probability of using outpatient and inpatient care and the number of visits increased with more NCD diagnoses (Table 2, Table 3). Respondents with a single NCD were 1.35 times more likely (95% CI 1.15–1.58) to have experienced an outpatient visit in the past four weeks compared with those without an NCD. The odds of an outpatient visit increased to 4.66 times (95% CI 3.55–6.11), while the incidence rate increased by 4.25 times (95% CI 3.33–5.42) in those with three or more NCDs. Furthermore, the incidence of inpatient visits was 3.68 times (95% CI 2.21–6.12) higher in those with three or more NCDs, compared with those without an NCD.

We reported the results of ICC in Table S3. We found that 14% and 11% of the variance in the outpatient visit were attributable to the differences within-individuals and households, respectively. Between-individual variation accounted for the largest variation, where it explained 75% (1-[0.14+0.11]) and 65% (1-[0.25+0.12]) of outpatient and inpatient visit, respectively. No influence of district–level variables was found (ICC=0).

Multimorbidity and financial burden

Table 2 presents the mean OOPE based on 2014 IFLS. The mean OOPE for outpatient care incurred by respondents during the last four weeks increased from INT$17 in those without any NCDs to INT$60 in those with three or more NCDs in 2014. Similarly, for inpatient visits, having three or more NCDs resulted in a higher mean OOPE of $762 (SD ±$1,421) compared with $566 (SD ±$1,880) for those without any NCDs. The total annual OOPE also increased from $295 (SD ±$977), among those without any NCDs, to $968 (SD ±$4,313) among those with three or more NCDs. Table 2 also

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presents the proportion of respondents with catastrophic health expenditure using different thresholds. The results using 10% and 25% of THE, and 40% of non-food consumption thresholds found that households with more than two NCDs had a higher proportion of catastrophic health expenditure compared with households without any member having any NCDs.

Table 4 presents the logistic regression results for the proportion of respondents who experienced catastrophic health expenditure using different thresholds. At 10% of THE as the threshold, having two NCDs increases the odds of catastrophic health expenditure to 1.58 times (95% CI 1.06–2.35), compared with having no NCD. These odds increased to 1.69 times for those having three NCDs or more (95% CI 1.02–2.81). At 25% and 40% thresholds, we found no significant association between the number of NCD and the incidence of catastrophic health expenditure.

Multimorbidity and productivity loss

More NCDs diagnoses were associated with greater productivity loss (Table 2, Table 5). For example, among those aged 50–60 years old, only 49.8% (95% CI 36.7–62.9) of respondents with three or more NCDs were employed, compared with 84.3% (95% CI 79.8–88.0) of respondents without NCD (Table 2). The mean number of days of primary daily activity missed increased from 2.7 days (SD ±6.0), for those without any NCDs, to 10.1 days (SD ±12.1) for those with three or more NCDs. The mean number of days confined to bed also increased among those with three or more NCDs.

Individuals diagnosed with three or more NCDs were 0.23 times less likely (95% CI 0.16–0.33) to be employed compared with those without NCD (Table 5). Compared

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with those without NCD, being diagnosed with three or more NCDs were expected to have a higher incidence rate of missing days of primary activity (IRR 2.59, 95% CI 1.97–3.41) as well as days confined in bed (IRR 2.64, 95% CI 1.60–4.36). We found that 48% of the variance in labour participation was due to within-individual variations, while between-individual variation accounted for 23% (1-[0.48+0.28+0.01]) (Table S3).

Robustness check

Our robustness analysis using 2014 cross-sectional dataset that consists of 14 physical NCDs (Table S4–7) showed consistent results with our original findings. Higher household expenditure and higher education were associated with a greater burden of multimorbidity. Multimorbidity was also associated with higher health care use, higher incidence of catastrophic health expenditures, and lower productivity. The association between multimorbidity and catastrophic health expenditure was more pronounced in the cross-sectional analysis. Our inclusion of obesity in the clustering of multimorbidity also yields consistent results (Table S8–10).

Discussion

Our study provides the first comprehensive analysis of multimorbidity in Indonesia using the only large panel dataset in Indonesia. Our study reveals that almost one in four of our study population has at least two NCDs, with 6.5% having three or more in 2014. Our findings show a higher prevalence of multimorbidity in wealthier population groups. Multimorbidity was associated with a higher use of healthcare services, higher probability of catastrophic health expenditure, and a reduction in productivity.

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Analyses of socioeconomic gradients of NCDs in HICs routinely find negative socioeconomic gradients. However, this is not the case for LMICs, which have a more mixed pattern of the distribution of risk factors.[34,35] Other studies find a similar pattern with diabetes and cardiovascular diseases in LMICs undergoing epidemiological transition.[35] These conditions predominate in high-income quintiles in early stages of transition, which may explain our findings on the higher prevalence of NCD multimorbidity among more affluent population. We also found that obesity was more prevalent in wealthier quintiles. As obesity is associated with several NCDs (cardiovascular diseases, hypertension, stroke, cancer, arthritis and hypercholesterolemia),[36] this may explain our findings on socioeconomic gradients of NCDs. Further, our results on socioeconomic patterning of multimorbidity can be explained by the fact that higher-income and higher-educational groups have better health literacy and access to healthcare services and thus, are more likely to have NCDs diagnosed than lower socio-income groups.

Our findings showing the association between having more NCDs and greater use of health services are in line with earlier studies from both HICs and LMICs.[9,28,37] The presence of NCD multimorbidity was also associated with a greater financial burden, which is mainly driven by higher healthcare use. These findings are consistent with earlier studies.[10,28,37,38] Based on a previous Indonesian study, four NCDs (hypertension, diabetes, heart problems, and stroke) are the leading causes of mortality and were estimated to account for 12% of Indonesia's OOPE in 2020.[22] Furthermore, the impoverishment effect of multimorbidity has been previously documented and is confirmed in our study.[7,21,22,37]

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This study contributes to the growing evidence that multimorbidity has a substantial impact on disability and productivity.[7,9,22] Interventions that can help effectively prevent and manage multimorbidity have the potential for generating substantial returns on improved health, work productivity and social benefits. However, a large portion of the Indonesia government health expenditure is still geared towards curative care.[5] Renewing the focus on health promotion and NCD prevention requires a strong PHC system.[9] PHC is the entry point of a sustainable health system for the early detection of risk factors and initiation of a treatment-seeking pathway for patients with NCDs, and thus, plays a crucial role for NCD prevention and provision of long-term integrated care. Such policies would be in line with the current program of the Ministry of Health in Indonesia to reorient public PHC to provide more promotive and preventive health services, such as through the implementation of Chronic Diseases Management Program (Prolanis) in PHC.[12,39] However, the participation in this program remains low due to the poor access to PHC facilities, especially in non-Java-Bali regions. Engaging the private sector, which makes up 60% of health facilities in Indonesia, is warranted to expand the coverage of NCDs promotive and prevention activities.[40] Furthermore, the development of digital health solution and telehealth for NCDs prevention and control should be included in the national plan.[41]

Although most countries and international health organisations have recognised the importance of multimorbidity,[42] most health policies and programs still focus on single diseases, including in Indonesia. Therefore, the health systems need to shift from single-disease models to new financing methods and service delivery to more effectively manage multimorbidity.[43,44] At the primary health care level, this can be

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done through improved prevention and treatment of multimorbidity, underpinned by multidisciplinary teams led by general practitioners.[42] There is also a need to strengthen the coordination of patient management between primary and secondary care. Similar to many LMICs and neighbouring countries in Asia, healthcare delivery in Indonesia remains fragmented and hospital-centred, with little coordination among healthcare providers across different tiers of the system.[45]

Furthermore, under the current national health insurance scheme, the hospital reimbursement system that uses case-based groups has created significant gaps between reimbursable costs and actual hospital expenses.[46] The reimbursement system, which is mainly based on primary diagnosis, limits the hospital's capacity and willingness to treat complicated cases such as those with multimorbidity.[47] Thus, while clinical guideline for single NCD still has a prominent role, it also important for LMICs to develop a clinical guideline for multimorbidity, along with payment systems that would ensure quality health services at both primary and secondary levels of care for patients with multimorbidity.[9,40] It is also worth noting that Indonesia is still facing the double burden of infectious and chronic diseases. Therefore, multimorbidity care delivery model needs to pay attention to the management of NCDs alongside infectious diseases.

There are several limitations to our study. First, the IFLS-5 was conducted between 2014 and 2015, which may not be able to capture the current prevalence of multimorbidity in Indonesia. Despite this limitation, IFLS is the only longitudinal survey available in Indonesia that is useful to produce more accurate estimates compared with using a cross-sectional dataset (e.g. the National Socioeconomic Survey). Second, our findings should be interpreted with caution since the assessment

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of NCDs was mostly based on self-reporting. This may cause misreporting of the true diagnoses and prevalence of multimorbidity. The health service use and OOPE were also based on self-reporting and may be prone to recall bias.[48] The use of self-reported diagnoses limits our assessment of the actual severity of the diseases, which may vary across socioeconomic status. Future studies should consider using different datasets (such as clinical dataset from the hospital) and applying clinical metrics such as Charlson index, which could more objectively capture disease severity and predict the health outcomes.[49] Third, the IFLS sample did not include eastern Indonesia. There is a need to extend the multimorbidity assessment to the remaining regions. Finally, this research intentionally focused on the older population due to a significantly higher burden of NCDs in this population group. Future research should use cohort data to follow patients over a more extended time period to examine the impact of multimorbidity and its effects in younger population groups in LMICs.[22]

Conclusion

Multimorbidity poses substantial costs to individuals, households, health system, and the wider society in Indonesia, which has an increasingly aging population. Policymakers and employers in Indonesia should carefully design and invest in targeted public health and workplace interventions at the individual and population level to avert the adverse health and economic consequences of NCD multimorbidity.

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Declarations

Abbreviation

CHE: Catastrophic health expenditure; HICs: High-income countries; IFLS: Indonesian Family Life Survey; LMICs: Low-middle income countries; NCDs: Noncommunicable diseases; OOPE: Out-of-pocket expenditure; PHC: Primary health care.

Competing interests

The authors have declared that no competing interests exist.

Ethics approval

The IFLS has been approved by ethics review boards at RAND Corporation and Gadjah Mada University in Indonesia. Written informed consent was sought from all respondents prior to data collection. As this study used IFLS publicly available datasets that contain no personal identification of the respondents, no further ethical approval was sought.

Author's contributions

Author's contributions: The aim of the research was developed by TM, KA, JL. The methodology development and analysis were conducted by TM, KA, HA, TP, JL. EH assisted in drafting the discussion section and proofread all section. YZ, HJ, MI contributed to background and discussion section. NN, BM, RA, JL provided critical input in revising the manuscript. All authors reviewed, edited and commented on multiple versions of the manuscript.

Availability of data and materials

The datasets are publicly accessible after registration (https://www.rand.org/well-being/social-and-behavioral-policy/data/FLS/IFLS/access.html).

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Figure captions

Figure 1. Prevalence of multimorbidity by age group and per capita household expenditure

[a] respondents who reported that they had 2 or more chronic conditions related to noncommunicable diseases (NCDs). [b] Pooled sample of Wave 4 and Wave 5. Q1-Q5 refer to household expenditure quintiles, where Q1 is the lowest and Q5 the highest household expenditure quintile.

Tables

Table 1. Sample characteristics and factors associated with multimorbidity

Characteristics	2007		2014		Factors associated with multimorbidity	
	Total n (%)	Multimorbidity % (95% CI)	Total n (%)	Multimorbidity % (95% CI)	aOR (95% CI)	p value
Overall	3678 (100%)	21.0 (19.6–22.6)	3678 (100%)	22.0 (20.6–23.6)		
Sex						
Male	1664 (46.1%)	14.1 (12.3–16.1)	1663 (46.0%)	19.4 (17.3–21.6)	1	
Female	2014 (53.9%)	26.9 (24.8–29.2)	2015 (54.0%)	24.3 (22.3–26.4)	1.74 (1.46–2.08)	<0.0001
Age						
50 – 60 years	2210 (59.8%)	19.9 (18.1–21.8)	966 (25.6%)	23.5 (20.7–26.7)	1	
61 – 70 years	1069 (29.9%)	21.9 (19.2–24.8)	1562 (42.9%)	21.6 (19.4–23.9)	1.10 (0.93–1.31)	0.257
71+ years	399 (10.3%)	25.2 (20.6–30.4)	1150 (31.4%)	21.4 (18.8–24.2)	1.09 (0.87–1.38)	0.444
Marital status						
Not currently married	927 (25.6%)	26.1 (23.0–29.4)	1338 (36.3%)	23.3 (20.9–25.9)	1	
Currently married	2751 (74.4%)	19.3 (17.7–21.1)	2340 (63.7%)	21.3 (19.5–23.2)	1.03 (0.86–1.24)	0.742
Educational level						
No education	2049 (58.7%)	20.4 (18.5–22.5)	2098 (60.6%)	18.0 (16.2–19.8)	1	
Primary	903 (24.8%)	19.7 (17.0–22.7)	862 (23.0%)	24.0 (20.9–27.3)	1.19 (0.98–1.44)	0.081
Junior high school	273 (6.4%)	25.9 (20.5–32.3)	271 (6.3%)	36.3 (30.2–43.0)	1.50 (1.12–2.02)	0.007
Senior high school	324 (7.2%)	20.5 (15.8–25.9)	307 (7.0%)	29.5 (24.1–35.5)	0.96 (0.71–1.29)	0.778
Tertiary	129 (2.9%)	34.4 (25.2–44.8)	140 (3.1%)	41.2 (31.6–51.6)	1.54 (1.01–2.34)	0.043
Ethnicity						
Javanese	1684 (51.8%)	19.4 (17.4–21.5)	1781 (55.8%)	19.7 (17.8–21.8)	1	
Sundanese	424 (15.9%)	29.1 (24.8–33.9)	438 (16.3%)	27.3 (23.1–31.8)	1.38 (1.08–1.77)	0.010
Others	1570 (32.3%)	19.6 (17,4–22.0)	1459 (27.9%)	23.6 (21.2–26.2)	1.10 (0.90–1.33)	0.355
Insurance coverage						
No	2652 (74.5%)	20.3 (18.6–22.1)	1950 (57.2%)	18.7 (16.9–20.7)	1	
Yes	1026 (25.5%)	23.2 (20.4–26.4)	1720 (42.8%)	26.4 (24.2–28.9)	1.18 (1.01–1.39)	0.035
Type of work						
Unemployed	951 (24.7%)	31.4 (28.1–34.9)	1483 (38.9%)	29.9 (27.4–32.6)	1	
Casual	674 (19.1%)	16.9 (13.9–20.4)	562 (14.1%)	13.8 (10.7–17.6)	0.47 (0.37–0.60)	<0.0001
Self-employed	1630 (45.2%)	16.8 (14.9–18.9)	1464 (40.1%)	17.4 (15.4–19.7)	0.61 (0.51–0.73)	<0.0001
Government/private	423 (10.9%)	22.2 (18.0–27.1)	269 (7.0%)	21.0 (15.8–27.4)	0.60 (0.45–0.79)	<0.0001
Per capita Household expenditure						
Q1 (the lowest)	728 (22.9%)	15.8 (13.0–18.9)	813 (25.2%)	13.5 (11.1–16.2)	1	
Q2	785 (22.4%)	17.9 (15.1–21.2)	746 (21.4%)	18.9 (15.9–22.3)	1.28 (1.01–1.62)	0.040
Q3	743 (20.1%)	20.5 (17.4–24.0)	757 (20.4%)	22.1 (18.9–25.7)	1.37 (1.08–1.74)	0.009
Q4	744 (18.4%)	23.6 (20.3–27.3)	681 (17.2%)	25.3 (21.9–29.0)	1.84 (1.44–2.33)	<0.0001
Q5 (the highest)	678 (16.1%)	30.4 (26.5–34.7)	681 (15.8%)	36.2 (32.2–40.5)	2.22 (1.72–2.86)	<0.0001
Residency						
Rural	1958 (63.4%)	18.1 (16.3–20.1)	1682 (52.8%)	16.9 (15.1–19.0)	1	
Urban	1720 (36.6%)	26.1 (23.8–28.6)	1996 (47.1%)	27.7 (25.5–30.0)	1.41 (1.19–1.67)	<0.0001
Region						
Java-Bali	2413 (77.5%)	21.6 (19.9–23.5)	2417 (77.6%)	21.1 (19.3–22.9)	1	
Sumatra	691 (14.5%)	19.6 (16.7–22.8)	690 (14.5%)	26.6 (23.3–30.2)	1.06 (0.85–1.33)	0.602
Nusa Tenggara	239 (2.4%)	14.5 (10.6–19.5)	239 (2.4%)	14.5 (10.5–19.6)	0.59 (0.40–0.87)	0.008
Kalimantan	168 (1.8%)	17.9 (12.7–24.5)	168 (1.7%)	34.2 (27.4–41.7)	1.35 (0.92–1.98)	0.129
Sulawesi	167 (3.8%)	19.6 (14.1–26.6)	164 (3.7%)	23.7 (17.6–31.0)	0.89 (0.59–1.34)	0.569

[a] Values are unweighted counts and weighted percentages unless otherwise indicated

[b] We defined multimorbidity if the respondents reported that they had 2 or more chronic conditions related to NCDs. Chronic diseases included: hypertension, diabetes, asthma, heart attack/coronary heart diseases, liver disease, stroke, cancer, arthritis/rheumatism, hypercholesterolemia, and mental illness.

[c] Adjusted odds ratio (aOR) was estimated using multilevel logistic regression model of 2007 and 2014 IFLS

NCD: noncommunicable disease

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Table 2. Descriptive summary of health service use-financial burden and productivity outcomes by the number of NCDs (2014 IFLS)

	No NCD	1 NCD	2 NCDs	+3 NCDs
	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
Overall (n, %)	1052 (100%)	1751 (100%)	627 (100%)	248 (100%)
Health service use				
Outpatient services [a)]				
Any visit (%, 95% CI)	15.5% (13.3–17.9)	21.7% (19.5–23.9)	35.7% (31.7–40.0)	55.9% (49.0–62.6)
Number of visits (mean, SD)	0.24 ± 0.72	0.41 ± 1.1	0.78 ± 1.6	1.4 ± 2.1
Inpatient services [b)]				
Any visit (%, 95% CI)	3.3% (2.3–4.8)	4.6% (3.5–6.0)	8.3% (6.1–11.0)	20.8% (15.7–27.0)
Number of visits (mean, SD)	0.04 ± 0.30	0.06 ± 0.31	0.14 ± 0.65	0.35 ± 0.96
Financial burden				
OOPE for outpatient care (mean, SD) [a,c)]	$17 ± 47	$17 ± 58	$15 ± 40	$60 ± 321
OOPE for inpatient care (mean, SD) [b,c)]	$566 ± 1,880	$527 ± 2,115	$792 ± 1,706	$762 ± 1,421
Annual Total OOPE (mean, SD)	$295 ± 977	$292 ± 1,239	$336 ± 950	$968 ± 4,313
Catastrophic health expenditure (%, 95% CI)				
>10% of total household expenditure	5.0% (3.7–6.6)	6.9% (5.6–8.5)	10.3% (7.9–13.4)	12.5% (8.7–17.7)
>25% of total household expenditure	1.5% (8.6–2.5)	1.5% (0.9–2.3)	2.8% (1.6–4.8)	2.8% (1.3–6.3)
>40% of total non-food expenditure	1.8% (1.1–2.8)	2.7% (1.9–3.6)	4.0% (2.6–6.2)	3.6% (1.8–6.8)
Productivity loss				
Labour participation (%, 95% CI)				
50-60 years[d)]	84.3% (79.8–88.0)	74.3% (69.3–7.8)	72.3% (64.3–79.1)	49.8% (36.7–62.9)
61-70 years [d)]	78.3% (74.0–82.1)	65.2% (61.1–69.1)	54.3% (47.1–61.3)	42.8% (32.6–53.8)
71+ years[d)]	51.4% (44.7–58.1)	45.0% (40.5–49.5)	28.4% (21.6–36.3)	17.3% (8.1–33.4)
Number of days of primary activity missed (mean, SD)	2.7 ± 6.0	3.6 ± 6.8	6.5 ± 9.8	10.1 ± 12.1
Number of days lying in bed (mean, SD)	0.80 ± 3.4	0.99 ± 3.6	1.9 ± 6.0	2.4 ± 6.3

[a)] in the last four weeks
[b)] in the last 12 months
[c)] Out-of-pocket expenditure (OOPE) were only asked to those who utilised outpatient and/or inpatient services.
[d)] The percentages were calculated based on the total number of respondents by aged groups. Total respondents aged 50-60 years, 61-70 years and 71+ years are 966, 1592, and 1150 respondents.
OOPE medical expenses were converted to 2014 International Dollars (INT$).
Bootstrapping with 400 times replications was performed to estimate the standard error and 95% CI.

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641 **Table 3. The effect of multimorbidity on health service use**

Variables	Health service use							
	Outpatient				Inpatient			
	Any visit[a)]		Number of visits[b)]		Any visit[a)]		Number of visits[b)]	
	aOR (95% CI)	p values	IRR (95% CI)	p values	aOR (95% CI)	p values	IRR (95% CI)	p values
Number of NCDs (ref. no NCD)								
Single NCD	1.35 (1.15–1.58)	<0.0001	1.45 (1.24–1.69)	<0.0001	1.07 (0.78–1.48)	0.671	1.06 (0.75–1.50)	0.755
Two NCDs	2.43 (2.00–2.95)	<0.0001	2.45 (2.04–2.93)	<0.0001	1.78 (1.23–2.57)	0.002	2.07 (1.39–3.08)	<0.0001
Three or more NCDs	4.66 (3.55–6.11)	<0.0001	4.25 (3.33–5.42)	<0.0001	3.69 (2.35–5.79)	<0.0001	3.68 (2.21–6.12)	<0.0001
Period (ref. 2007)								
2014	1.40 (1.22–1.61)	<0.0001	1.46 (1.29–1.65)	<0.0001	1.79 (1.36–2.36)	<0.0001	2.20 (1.63–2.98)	<0.0001
Sex (ref. Male)								
Female	1.26 (1.08–1.47)	0.003	1.20 (1.04–1.39)	0.013	0.93 (0.70–1.24)	0.626	0.85 (0.62–1.16)	0.300
Age (ref. 50 – 60 years)								
61 – 70 years	1.01 (0.86–1.18)	0.905	1.00 (0.87–1.16)	0.969	1.07 (0.78–1.45)	0.677	1.17 (0.84–1.65)	0.351
71+ years	1.10 (0.90–1.34)	0.351	1.06 (0.88–1.27)	0.567	1.49 (1.03–2.15)	0.034	1.66 (1.11–2.49)	0.014
Marital status (ref. Not married)								
Currently married	1.14 (0.97–1.34)	0.105	1.15 (0.99–1.34)	0.069	1.04 (0.77–1.40)	0.815	0.98 (0.71–1.37)	0.914
Educational level (ref. No education)								
Primary	1.06 (0.90–1.25)	0.496	0.96 (0.82–1.13)	0.629	1.09 (0.80–1.50)	0.578	0.97 (0.69–1.38)	0.882
Junior high school	1.04 (0.80–1.35)	0.786	1.00 (0.78–1.28)	0.993	1.23 (0.78–1.95)	9,40 0.368	1.48 (0.90–2.42)	0.120
Senior high school	1.05 (0.81–1.36)	0.706	0.91 (0.71–1.17)	0.473	0.91 (0.57–1.46)	0.699	0.82 (0.49–1.37)	0.448
Tertiary	1.29 (0.90–1.84)	0.167	0.93 (0.66–1.32)	0.697	0.98 (0.53–1.80)	0.937	0.85 (0.42–1.69)	0.640
Ethnicity (ref. Javanese)								
Sundanese	0.92 (0.74–1.14)	0.464	0.95 (0.77–1.16)	0.617	0.90 (0.61–1.34)	0.609	1.14 (0.75–1.76)	0.536
Others	1.06 (0.89–1.25)	0.525	0.99 (0.84–1.16)	0.877	0.90 (0.65–1.23)	0.495	1.08 (0.76–1.52)	0.676
Insurance coverage (ref. No)								
Yes	1.48 (1.28–1.70)	<0.0001	1.51 (1.32–1.72)	<0.0001	1.90 (1.45–2.50)	<0.0001	1.65 (1.23–2.21)	0.001
Type of work (ref. Unemployed)								
Casual	0.76 (0.62–0.95)	0.014	0.69 (0.57–0.85)	<0.0001	0.49 (0.31–0.78)	0.003	0.44 (0.27–0.73)	0.001
Self-employed	0.85 (0.73–1.00)	0.056	0.82 (0.70–0.95)	0.008	0.60 (0.44–0.82)	0.001	0.60 (0.43–0.83)	0.002
Government/private	0.75 (0.58–0.96)	0.025	0.72 (0.57–0.92)	0.008	0.63 (0.39–1.04)	0.071	0.77 (0.46–1.31)	0.335
Per capita household expenditure (ref. Q1)								
Q2	1.50 (1.21–1.86)	<0.0001	1.50 (1.23–1.84)	<0.0001	1.25 (0.81–1.92)	0.307	1.07 (0.67–1.70)	0.777
Q3	1.76 (1.42–2.18)	<0.0001	1.74 (1.42–2.13)	<0.0001	1.64 (1.08–2.49)	0.020	1.71 (1.10–2.66)	0.018
Q4	1.73 (1.38–2.15)	<0.0001	1.80 (1.46–2.21)	<0.0001	1.42 (0.91–2.20)	0.121	1.36 (0.86–2.18)	0.192
Q5	1.90 (1.51–2.40)	<0.0001	2.09 (1.68–2.59)	<0.0001	2.48 (1.60–3.85)	<0.0001	2.52 (1.59–4.00)	<0.0001
Residency (ref. Rural)								
Urban	0.92 (0.80–1.07)	0.283	0.95 (0.83–1.10)	0.500	0.96 (0.72–1.26)	0.744	1.05 (0.78–1.42)	0.726
Region (ref. Java-Bali)								
Sumatra	0.83 (0.68–1.00)	0.052	0.98 (0.81–1.17)	0.798	1.23 (0.87–1.74)	0.236	1.25 (0.86–1.82)	0.250
Nusa Tenggara	0.64 (0.46–0.89)	0.007	0.60 (0.43–0.82)	0.002	1.25 (0.71–2.18)	0.437	1.11 (0.60–2.03)	0.745
Kalimantan	1.03 (0.74–1.43)	0.873	1.21 (0.89–1.65)	0.228	1.09 (0.58–2.05)	0.799	0.94 (0.47–1.89)	0.865
Sulawesi	0.64 (0.45–0.93)	0.019	0.63 (0.44–0.90)	0.011	0.63 (0.30–1.35)	0.235	0.63 (0.29–1.38)	0.249

[a)] Multilevel logistic regression model
[b)] Multilevel negative binomial regression model
aOR: adjusted odds ratio, IRR: Incidence rate ratio, NCD: noncommunicable disease

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643 **Table 4. The effect of multimorbidity on catastrophic expenditure**

Variables	Catastrophic health expenditure					
	10% of total household expenditure[a)]		25% of total household expenditure[a)]		40% of non-food expenditure [a)]	
	aOR (95% CI)	p values	aOR (95% CI)	p values	aOR (95% CI)	p values
Number of NCDs (ref. no NCD)						
Single NCD	1.11 (0.76–1.62)	0.591	0.81 (0.49–1.34)	0.417	0.86 (0.52–1.43)	0.561
Two NCDs	1.58 (1.06–2.35)	0.026	1.39 (0.79–2.45)	0.250	1.27 (0.69–2.35)	0.437
Three or more NCDs	1.69 (1.02–2.81)	0.042	0.96 (0.40–2.34)	0.937	0.72 (0.27–1.89)	0.503
Period (ref. 2007)						
2014	1.42 (1.12–1.80)	0.003	1.27 (0.83–1.95)	0.271	1.18 (0.77–1.80)	0.442
Sex (ref. Male)						
Female	0.89 (0.64–1.23)	0.480	0.90 (0.57–1.42)	0.645	0.83 (0.52–1.33)	0.432
Age (ref. 50 – 60 years)						
61 – 70 years	1.15 (0.79–1.69)	0.461	1.46 (0.90–2.36)	0.125	1.43 (0.85–2.38)	0.175
71+ years	1.13 (0.66–1.92)	0.663	1.01 (0.51–2.01)	0.975	1.24 (0.60–2.55)	0.563
Marital status (ref. Not married)						
Currently married	1.59 (1.22 – 2.09)	0.001	1.68 (0.98–2.87)	0.060	1.83 (1.01–3.33)	0.047
Educational level (ref. No education)						
Primary	0.96 (0.67–1.38)	0.841	0.90 (0.52–1.55)	0.708	0.85 (0.48–1.52)	0.589
Junior high school	0.97 (0.64–1.47)	0.902	1.21 (0.58–2.55)	0.610	0.60 (0.25–1.48)	0.271
Senior high school	0.93 (0.61–1.42)	0.735	1.22 (0.59–2.52)	0.595	0.81 (0.34–1.92)	0.627
Tertiary	0.45 (0.22–0.90)	0.023	0.11 (0.01–0.94)	0.043	0.12 (0.02–0.84)	0.032
Ethnicity (ref. Javanese)						
Sundanese	0.87 (0.62–1.23)	0.433	1.80 (0.98–3.33)	0.060	1.14 (0.52–2.48)	0.748
Others	0.76 (0.56–1.02)	0.065	1.01 (0.58–1.78)	0.959	0.56 (0.28–1.09)	0.088
Insurance coverage (ref. No)						
Yes	0.89 (0.67–1.20)	0.451	0.83 (0.53–1.31)	0.425	0.80 (0.49–1.32)	0.390
Type of work (ref. Unemployed)						
Casual	0.59 (0.33–1.07)	0.082	0.58 (0.29–1.17)	0.128	0.41 (0.20–0.84)	0.015
Self-employed	0.60 (0.36–1.01)	0.056	0.58 (0.35–0.96)	0.033	0.45 (0.27–0.76)	0.003
Government/private	0.58 (0.34–1.02)	0.058	0.78 (0.35–1.70)	0.527	0.39 (0.16–0.95)	0.038
Per capita household expenditure (ref. Q1)						
Q2	1.04 (0.071- 1.52)	0.834	1.60 (0.71–3.57)	0.257	1.34 (0.62–2.90)	0.459
Q3	1.37 (0.97–1.95)	0.076	1.71 (0.77–3.80)	0.188	1.19 (0.54–2.61)	0.669
Q4	1.98 (1.40–2.81)	<0.0001	3.11 (1.43–6.76)	0.004	2.73 (1.23–6.03)	0.013
Q5	3.13 (2.28–4.31)	<0.0001	5.91 (2.72–12.85)	<0.0001	8.45 (3.70–19.32)	<0.0001
Residency (ref. Rural)						
Urban	0.94 (0.61–1.45)	0.785	0.76 (0.46–1.24)	0.273	0.75 (0.43–1.31)	0.309
Region (ref. Java-Bali)						
Sumatra	0.78 (0.56–1.09)	0.146	0.73 (0.38–1.38)	0.328	1.08 (0.52–2.24)	0.846
Nusa Tenggara	0.64 (0.34 – 1.21)	0.175	0.98 (0.32–2.99)	0.968	0.93 (0.22–3.83)	0.917
Kalimantan	0.78 (0.39–1.52)	0.460	0.64 (0.19–2.24)	0.488	0.64 (0.15–2.77)	0.548
Sulawesi	0.80 (0.43–1.48)	0.478	1.21 (0.41–3.57)	0.724	1.31 (0.33–5.17)	0.701

[a)] Multilevel logistic regression model

aOR: adjusted odds ratio, NCD: noncommunicable disease

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645 **Table 5. The effect of multimorbidity on productivity loss**

Variables	Productivity loss					
	Labour participation[a)]		Days primary activity missed[b)]		Days confined in bed[b)]	
	aOR (95% CI)	p values	IRR (95% CI)	p values	IRR (95% CI)	p values
Number of NCDs (ref. no NCD)						
Single NCD	0.65 (0.54–0.79)	<0.0001	1.25 (1.08–1.43)	0.002	1.09 (0.84–1.43)	0.509
Two NCDs	0.45 (0.35–0.57)	<0.0001	1.90 (1.58–2.29)	<0.0001	1.87 (1.33–2.61)	<0.0001
Three or more NCDs	0.23 (0.16–0.33)	<0.0001	2.59 (1.97–3.41)	<0.0001	2.64 (1.60–4.36)	<0.0001
Period (ref. 2007)						
2014	0.69 (0.59–0.81)	<0.0001	1.66 (1.46–1.88)	<0.0001	1.79 (1.40–2.29)	<0.0001
Sex (ref. Male)						
Female	0.21 (0.17–0.26)	<0.0001	0.99 (0.86–1.14)	0.912	0.92 (0.70–1.21)	0.567
Age (ref. 50 – 60 years)						
61 – 70 years	0.37 (0.31–0.45)	<0.0001	0.99 (0.86–1.14)	0.859	1.07 (0.81–1.41)	0.617
71+ years	0.10 (0.07–0.13)	<0.0001	1.20 (1.00–1.44)	0.047	1.93 (1.37–2.72)	<0.0001
Marital status (ref. Not married)						
Currently married	1.51 (1.23–1.84)	<0.0001	1.13 (0.98–1.31)	0.089	0.88 (0.67–1.17)	0.395
Educational level (ref. No education)						
Primary	0.89 (0.71–1.11)	0.305	0.92 (0.79–1.07)	0.263	1.00 (0.75–1.33)	0.999
Junior high school	0.41 (0.29–0.57)	<0.0001	0.94 (0.74–1.20)	0.631	0.87 (0.54–1.40)	0.570
Senior high school	0.41 (0.29–0.58)	<0.0001	0.68 (0.53–0.87)	0.002	0.81 (0.51–1.28)	0.362
Tertiary	0.51 (0.31–0.82)	0.006	0.54 (0.38–0.78)	0.001	0.37 (0.18–0.78)	0.009
Ethnicity (ref. Javanese)						
Sundanese	0.50 (0.37–0.67)	<0.0001	1.35 (1.11–1.65)	0.003	1.28 (0.89–1.85)	0.179
Others	0.77 (0.61–0.98)	0.033	1.11 (0.95–1.30)	0.188	1.12 (0.84–1.49)	0.436
Insurance coverage (ref. No)						
Yes	0.85 (0.72–1.01)	0.071	1.08 (0.95–1.22)	0.258	1.05 (0.82–1.34)	0.704
Type of work (ref. Unemployed)						
Casual	N/A	N/A	0.62 (0.51–0.75)	<0.0001	0.32 (0.22–0.47)	<0.0001
Self-employed	N/A	N/A	0.62 (0.53–0.71)	<0.0001	0.42 (0.32–0.56)	<0.0001
Government/private	N/A	N/A	0.57 (0.45–0.72)	<0.0001	0.45 (0.28–0.73)	0.001
Per capita household expenditure (ref. Q1)						
Q2	1.37 (1.08–1.75)	0.011	1.03 (0.86–1.23)	0.744	1.05 (0.74–1.49)	0.769
Q3	1.33 (1.03–1.71)	0.028	1.15 (0.96–1.38)	0.130	1.06 (0.75–1.50)	0.737
Q4	1.12 (0.87–1.46)	0.379	1.05 (0.87–1.27)	0.627	1.02 (0.71–1.46)	0.914
Q5	1.34 (1.01–1.77)	0.043	1.29 (1.05–1.58)	0.015	0.92 (0.63–1.35)	0.668
Residency (ref. Rural)						
Urban	0.44 (0.35–0.54)	<0.0001	0.93 (0.81–1.07)	0.296	0.70 (0.54–0.89)	0.004
Region (ref. Java-Bali)						
Sumatra	0.95 (0.73–1.25)	0.735	1.13 (0.94–1.–36)	0.194	1.01 (0.73–1.40)	0.956
Nusa Tenggara	0.74 (0.48–1.14)	0.177	0.90 (0.68–1.20)	0.472	1.14 (0.67–1.93)	0.638
Kalimantan	1.21 (0.75–1.94)	0.440	0.90 (0.67–1.22)	0.511	0.89 (0.51–1.57)	0.688
Sulawesi	0.39 (0.24–0.62)	<0.0001	0.99 (0.72–1.36)	0.948	0.94 (0.53–1.69)	0.845

[a)] Multilevel logistic regression model
[b)] Multilevel negative binomial regression model
aOR: adjusted odds ratio, IRR: incidence rate ratio, NCD: noncommunicable disease

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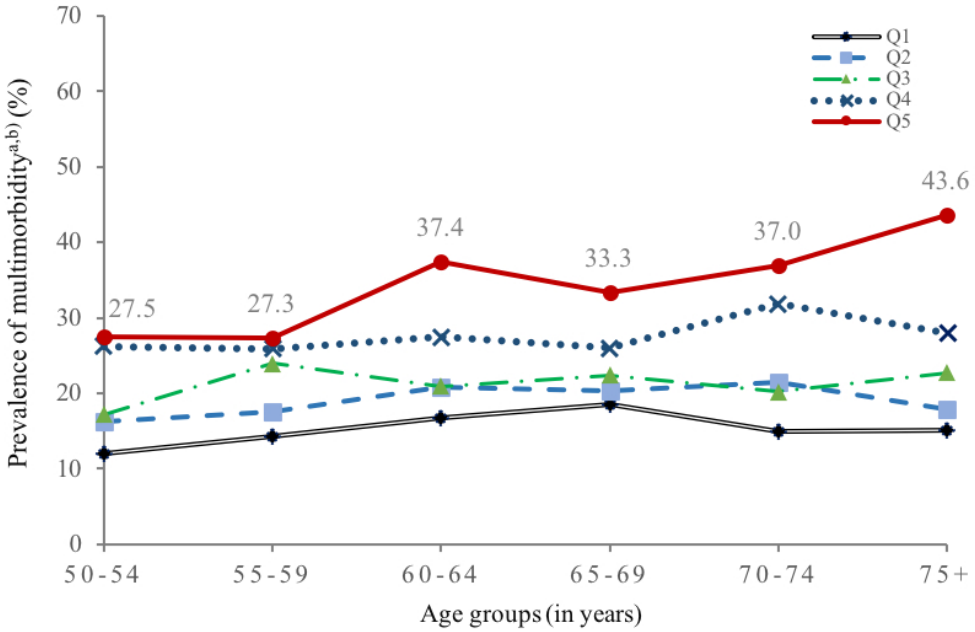

Figure 1. Prevalence of multimorbidity by age group and per capita household expenditure
a) respondents who reported that they had 2 or more chronic conditions related to non-communicable diseases (NCDs). b) Pooled sample of Wave 4 and Wave 5. Q1-Q5 refer to household expenditure quintiles, where Q1 is the lowest and Q5 the highest household expenditure quintile.

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SUPPLEMENTAL MATERIAL

Figure S1. Sample flowchart

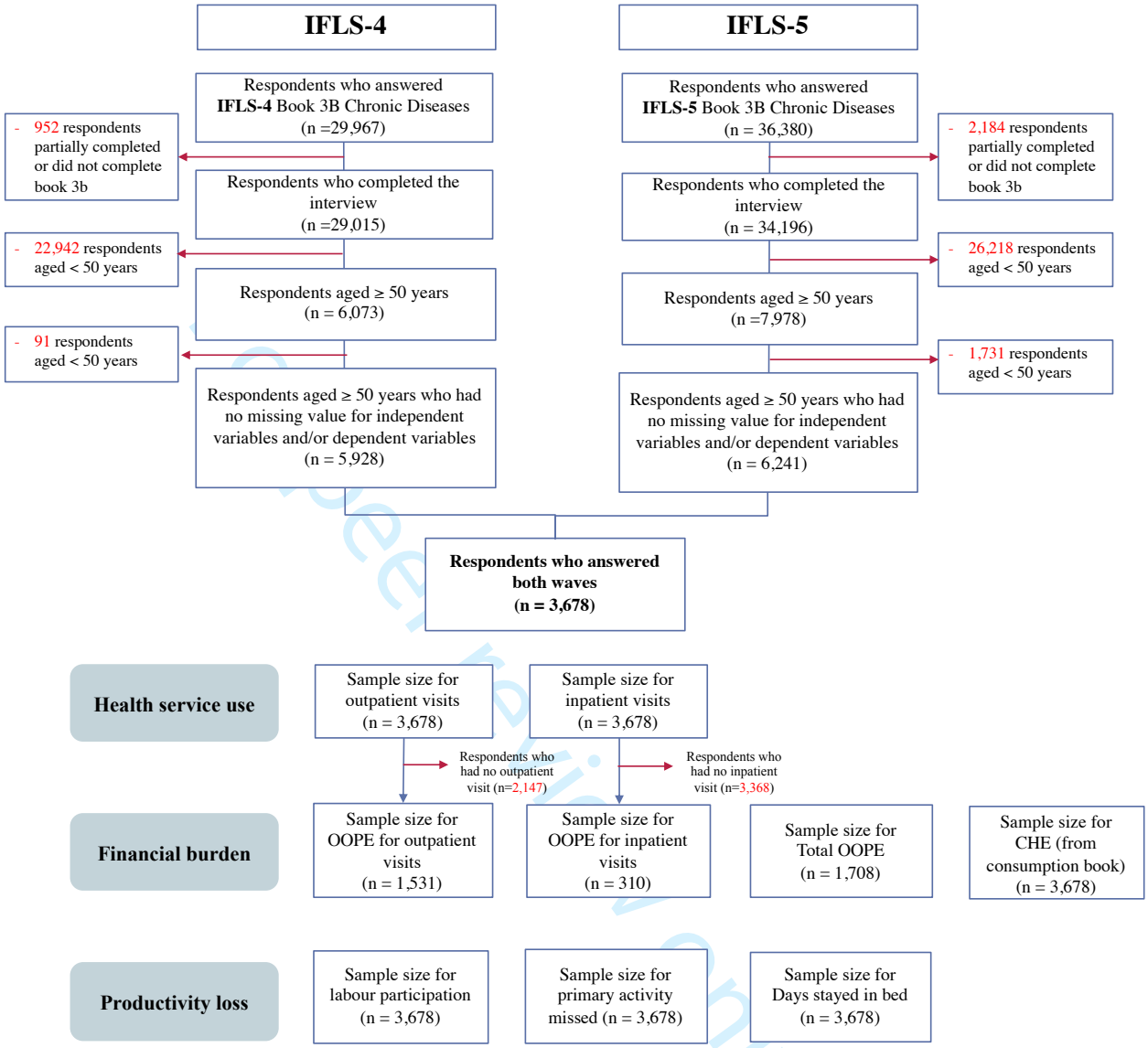

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Table S1. List of variables for 2007 & 2014 IFLS analysis

Variables	Type	Measurement	Source of measurement
Dependent variables:			
1) Health service use			
Outpatient care	Binary	0. No 1. Yes	RJ00: In the last 4 weeks have you visited a public hospital-*puskesmas*-private hospital-clinic-health worker or doctor's practice or been visited by a health worker or doctor?
	Numerical	Number of days	RJ02: How many times did you visit / been visited by [...] during the last 4 weeks?
Inpatient care	Binary	0. No 1. Yes	RN00: During the past 12 months have you ever received patient care at a hospital-*puskesmas*-clinic-or other?
	Numerical	Number of days	RN02: How many times have you received inpatient care at […] during the past 12 months?
2) Productivity loss			
Labour participation	Binary	0. No 1. Yes	TK06a: Did you work/try to work/help to earn income for pay for at least 1 hour during the past week?
	Numerical	Number of days	
Activity missed due to poor health	Numerical	Number of days	KK02a: During the last 4 weeks-how many days of your primary daily activities did you miss due to poor health?
Stayed in bed	Numerical	Number of days	KK02b: In the last 4 weeks-how many days have you stayed in bed due to poor health?
3) Financial burden			
OOPE of outpatient care	Numerical	International Dollars	RJ02b: How much did you pay out of pocket for outpatient care at […] during the past 4 weeks?
OOPE of inpatient care	Numerical	International Dollars	RN02b: How much did you pay out of pocket for inpatient care at […] during the past 12 months?
Annual Total OOPE	Numerical	International Dollars	Annual total OOPE for outpatient and inpatient visits
Catastrophic health expenditure	Binary	0. No 1. Yes	Book KS: "How much money spent by all household members for medical costs during the past year?"
Main independent variable			
Number of NCDs	Numerical	Total number of chronic conditions related to NCDs	Book IIIB: CD06a – CD06r: Have a doctor/paramedic/nurse/ midwife ever told you that you had [list of chronic diseases]
	Categorical ordinal	2. No 3. 1 NCD 4. 2 NCDs	

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Variables	Type	Measurement	Source of measurement
		5. 3+ NCDs	
Multimorbidity	Binary	0. No 1. Yes (had 2 or more chronic conditions related to NCDs)	Book IIIB: CD06a – CD06r: Have a doctor/paramedic/nurse/ midwife ever told you that you had [list of chronic diseases]
List of chronic diseases included in the main analysis: Hypertension, diabetes, asthma, heart attack/coronary heart diseases, liver disease, stroke, cancer, arthritis/rheumatism, hypercholesterolemia, and depression/mental illness. List of chronic diseases in 2007 IFLS (Wave 4): Hypertension, diabetes, asthma, heart attack/coronary heart diseases, liver disease, stroke, cancer, arthritis/rheumatism, hypercholesterolemia, and depression/mental illness. List of chronic diseases in 2014 IFLS (Wave 5): Hypertension, diabetes, asthma, heart attack/coronary heart diseases, liver disease, stroke, cancer, arthritis/rheumatism, hypercholesterolemia, mental illness, prostate diseases, kidney diseases (excluding malignancy), digestive diseases, and memory-related diseases.			
Covariates			
Age (in years)	Categorical ordinal	0. 40-49 years 1. 50-59 years 2. 60-69 years 3. 70-79 years 4. 80+	Book IIIA: Age: How old are you?
Sex	Binary	0. Male 1. Female	Book IIIA: Sex: (identified by interviewers)
Ethnicity	Categorical nominal	0. Javanese 1. Sundanese 2. Others	
Marital status	Binary	0. Unmarried/Divorce 1. Married or living together	Book IIIA HR00b: Are you currently married?
Education	Categorical ordinal	0. None 1. Elementary school 2. Junior high school 3. High school 4. Tertiary	Book IIIA: DL06: What is the highest education level attended? DL07: What is the highest grade completed at school.
Occupation	Categorical nominal	0. None 1. Casual worker 2. Self-employed 3. Government/private worker	Book IIIA: TK06a: Did you work/try to work/help to earn income for pay for at least 1 hour during the past week? TK15: Which category best describes the work you did in your last job?
Health insurance status	Binary	0. Uninsured (Not covered by any insurance) 1. Insured	Book IIIB: AK01: Are you the policy holder/primary beneficiary of health benefits-health insurance?
Per capita expenditure	Categorical ordinal	0. Q1 (lowest) 1. Q2 2. Q3 3. Q4 4. Q5 (highest)	Book KS
Residency	Binary	0. Rural 1. Urban	Book T-2: SC06: (identified by interviewers)
Region	Categorical nominal	0. Java-Bali 1. Sumatra 2. Nusa Tenggara 3. Kalimantan 4. Sulawesi	Book T-2: SC01: province (identified by interviewers)

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Table S2. Sample characteristics by number of NCDs

Characteristics	2007 (n=3,678)			2014 (n=3,678)		
	Zero NCD (n=1,272)	One NCD (n=1,605)	Multimorbidity (n=801)	Zero NCD (n=1,052)	One NCD (n=1,751)	Multimorbidity (n=875)
Sex						
Male	44.2 (41.5–46.9)	41.7 (39.1–44.5)	14.1 (12.3–16.1)	34.7 (32.1–37.3)	45.9 (43.2–48.7)	19.3 (17.3–21.6)
Female	28.9 (26.7–31.3)	44.2 (41.7–46.7)	26.9 (24.8–29.2)	24.6 (22.5–26.8)	51.1 (48.6–53.6)	24.3 (22.3–26.4)
Age						
50 – 60 years	39.9 (37.55–42.2)	40.3 (38.0–42.6)	19.9 (18.1–21.8)	36.4 (33.0–39.9)	40.1 (36.6–43.7)	23.5 (20.7–26.7)
61 – 70 years	32.3 (29.1–35.6)	45.9 (42.5–49.3)	21.9 (19.2–24.8)	30.2 (27.7–32.9)	48.2 (45.4–51.0)	21.6 (19.4–23.9)
71+ years	23.9 (19.2–29.3)	50.9 (45.2–56.6)	25.2 (20.6–30.4)	22.0 (19.4–25.0)	56.6 (53.2–59.8)	21.4 (18.8–24.2)
Marital status						
Not currently	25.6 (22.5–29.0)	48.3 (44.6–52.0)	26.1 (23.0–29.4)	23.8 (21.2–26.5)	52.9 (49.9–56.0)	23.3 (20.9–25.9)
married	39.5 (37.4–41.6)	41.2 (39.1–43.4)	19.3 (17.7–21.1)	32.4 (30.2–34.6)	46.3 (44.0–48.7)	21.3 (19.5–23.2)
Currently married						
Educational level						
No education	24.8 (32.5–37.2)	44.8 (42.3–47.2)	20.4 (18.5–22.5)	29.6 (27.4–31.9)	52.4 (50.0–54.8)	18.0 (16.2–19.8)
Primary	40.5 (36.9–44.2)	39.8 (36.2–46/3)	19.7 (17.0–22.7)	28.6 (25.3–32.1)	47.5 (43.7–51.3)	24.0 (20.9–27.3)
Junior high school	34.4 (28.3–41.1)	39.6 (33.4–46.3)	25.9 (20.5–32.3)	31.6 (25.6–38.3)	32.1 (26.1–38.7)	36.3 (30.2–43.0)
Senior high school	35.9 (30.2–42.1)	43.6 (37.5–49.8)	20.5 (15.8–25.9)	28.9 (23.4–35.0)	41.6 (35.6–48.0)	29.5 (24.1–35.5)
Tertiary	23.7 (16.2–33.2)	41.9 (32.1–52.4)	34.4 (25.2–44.8)	23.0 (15.8–32.2)	35.7 (27.0–45.5)	41.2 (31.6–51.6)
Ethnicity						
Javanese	37.0 (34.5–39.6)	43.6 (41.0–46.2)	19.4 (17.4–21.5)	29.7 (27.4–32.1)	50.6 (48.1–53.2)	19.7 (17.8–21.8)
Sundanese	30.4 (25.9–35.2)	40.5 (35.7–45.5)	29.1 (24.8–33.9)	23.5 (19.6–27.9)	49.3 (44.3–54.2)	27.3 (23.1–31.8)
Others	37.0 (34.2–39.9)	43.4 (40.5–46.3)	19.6 (17,4–22.0)	31.7 (29.0–34.7)	44.6 (41.6–47.7)	23.6 (21.2–26.2)
Insurance coverage						
No	36.5 (34.4–38.6)	43.2 (41.1–45.4)	20.3 (18.6–22.1)	31.1 (28.9–33.5)	50.2 (47.7–52.7)	18.7 (16.9–20.7)
Yes	34.2 (30.9–37.7)	42.5 (39.1–46.0)	23.2 (20.4–26.4)	26.7 (24.3–29.2)	46.8 (44.1–49.6)	26.4 (24.2–28.9)
Type of work						
Unemployed	22.5 (19.6–25.6)	46.2 (42.6–49.8)	31.4 (28.1–34.9)	19.6 (17.4–22.1)	50.4 (47.5–53.3)	29.9 (27.4–32.6)
Casual	41.8 (37.6–46.1)	41.3 (37.2–45.6)	16.9 (13.9–20.4)	36.5 (31.6–41.6)	49.7 (44.6–54.8)	13.8 (10.7–17.6)
Self-employed	41.1 (38.4–43.9)	42.1 (39.4–44.8)	16.8 (14.9–18.9)	34.2 (31.5–37.0)	48.4 (45.4–51.3)	17.4 (15.4–19.7)
Government/priva	34.8 (29.8–40.2)	43.0 (37.7–48.4)	22.2 (18.0–27.1)	39.6 (33.0–46.5)	39.4 (32.9–46.3)	21.0 (15.8–27.4)
te						
Household						
expenditure						
Q1 (the lowest)	39.9 (36.0–43.9)	44.1 (40.1–48.1)	15.8 (13.0–18.9)	30.9 (27.5–34.6)	55.6 (51.8–59.3)	13.5 (11.1–16.2)
Q2	39.6 (35.7–43.6)	42.4 (38.6–46.4)	17.9 (15.1–21.2)	31.6 (27.9–35.5)	49.5 (45.4–53.6)	18.9 (15.9–22.3)
Q3	36.4 (32.5–40.5)	43.1(39.1–47.2)	20.5 (17.4–24.0)	31.4 (27.7–35.3)	46.5 (42.5–50.6)	22.1 (18.9–25.7)
Q4	31.7 (27.9–35.7)	44.6 (40.5–48.7)	23.6 (20.3–27.3)	27.0 (23.3–31.1)	47.8 (43.4–52.1)	25.3 (21.9–29.0)
Q5 (the highest)	28.8 (24.9–33.0)	40.5 (36.3–44.9)	30.4 (26.5–34.7)	23.1 (19.6–27.0)	40.7 (36.5–45.0)	36.2 (32.2–40.5)
Residency						
Rural	38.7 (36.3–41.1)	43.2 (40.8–45.7)	18.1 (16.3–20.1)	31.0 (28.6–33.5)	52.1 (49.4–54.7)	16.9 (15.1–19.0)
Urban	31.2 (28.7–33.7)	42.7 (40.1–45.4)	26.1 (23.8–28.6)	27.3 (25.1–29.6)	45.0 (42.5–47.5)	27.7 (25.5–30.0)
Island						
Java-Bali	36.5 (34.4–38.7)	41.9 (39.7–44.1)	21.6 (19.9–23.5)	29.7 (27.7–31.7)	49.3 (47.1–51.5)	21.1 (19.3–22.9)
Sumatra	34.6 (31.0–38.4)	45.9 (42.0–49.8)	19.6 (16.7–22.8)	27.9 (24.6–31.6)	45.4 (41.6–49.4)	26.6 (23.3–30.2)
Nusa Tenggara	44.0 (37.7–50.5)	41.6 (35.3–48.1)	14.5 (10.6–19.5)	31.4 (25.7–37.7)	54.1 (47.6–60.5)	14.5 (10.5–19.6)
Kalimantan	25.2 (19.2–32.4)	56.9 (49.0–64.4)	17.9 (12.7–24.5)	23.4 (17.6–30.6)	42.4 (35.0–50.1)	34.2 (27.4–41.7)
Sulawesi	30.0 (23.3–37.6)	50.4 (42.6–58.2)	19.6 (14.1–26.6)	26.7 (20,3–34.2)	49.7 (41.8–57.5)	23.7 (17.6–31.0)
Overall (N, %)	1,272 (35.9)	1,605 (43.0)	801 (21.0)	1,052 (29.2)	1,751 (48.7)	875 (22.0)

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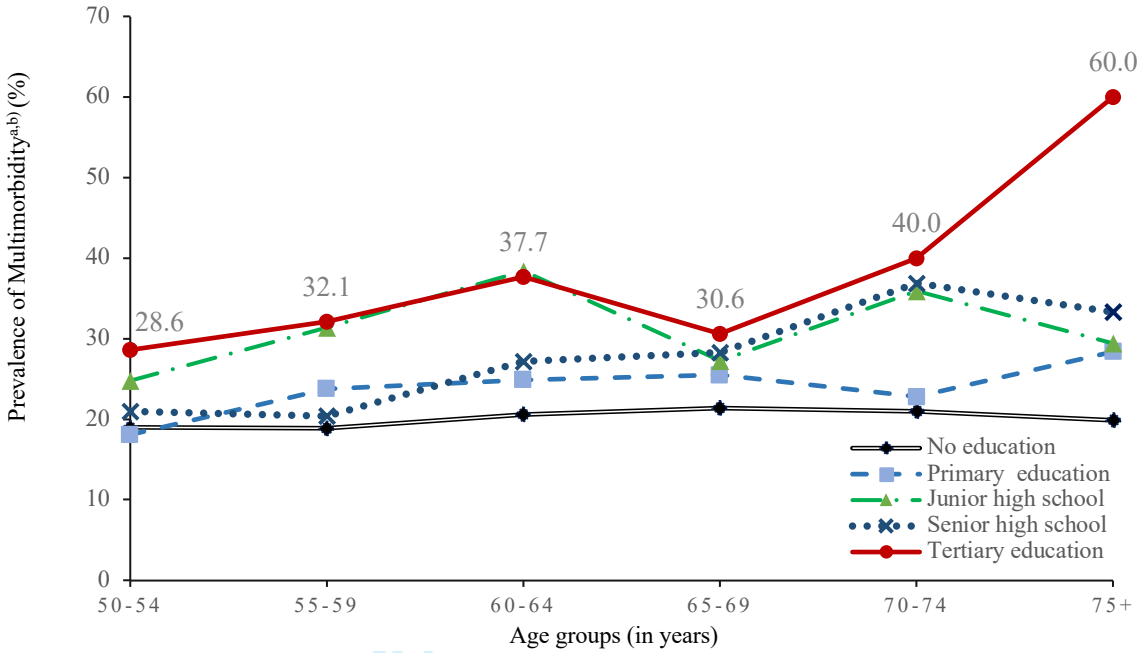
Figure S2. Prevalence of multimorbidity by age group and level of education



[a)] respondents who reported that they had 2 or more chronic conditions related to noncommunicable diseases (NCDs). [b)] Pooled sample of Wave 4 and Wave 5.

Table S3. Intraclass correlation coefficients (ICC) on multimorbidity, health service use and labour participation

	Multimorbidity	Any outpatient visit	Any inpatient visit	10% of total household expenditure	25% of total household expenditure	40% of non-food expenditure	Labour participation
Individual							
Variance (SE)	1.09 (0.25)	0.10 (0.18)	0.57 (0.74)	0 (0)	0 (0)	0 (0)	1.22 (0.30)
ICC (SE)	0.34 (0.03)	0.14 (0.03)	0.25 (0.12)	0.25 (0.03)	0.48 (0.04)	0.69 (0.04)	0.48 (0.03)
Household							
Variance (SE)	0.64 (0.20)	0.43 (0.14)	0.54 (0.57)	1.13 (0.20)	3.08 (0.55)	7.29 (1.3)	1.70 (0.28)
ICC (SE)	0.13 (0.40)	0.11 (0.04)	0.12 (0.12)	0.25 (0.03)	0.48 (0.04)	0.69 (0.04)	0.28 (0.04)
District							
Variance (SE)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.07 (0.04)
ICC (SE)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.01 (0.01)

Note:
All models are controlled for study variables, including sex, age, marital status, education, ethnicity, insurance coverage, type of work, per capita expenditure (PCE), residency, and region. SE: standard error. ICC: intraclass correlation

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Table S4. Robustness check: descriptive summary and factors associated with multimorbidity (cross-sectional analysis of 2014 IFLS)

Characteristics	Weighted % Of sample	Zero NCD (%, 95% CI)	One NCD (%, 95% CI)	Two NCDs (%, 95% CI)	Three or more NCDs (%, 95% CI)	Multimorbidity[b] (%, 95% CI)	Multimorbidity[b] aOR (95% CI)
Sex							
Female	51.9	24.8 (22.3, 26.3)	46.1 (44.4, 47.8)	18.8 (17.5, 20.1)	10.3 (9.3, 11.4)	29.1 (27.6, 30.6)	1
Male	48.1	36.5 (34.7, 38.3)	42.0 (40.2, 43.9)	14.0 (12.8, 15.4)	7.4 (6.5, 8.4)	21.5 (20.0, 23.0)	0.68*** (0.59–0.78)
Age							
50 – 60 years	56.2	35.3 (33.7, 37.1)	41.0 (39.3, 42.7)	15.2 (14.0, 16.5)	8.5 (7.6, 9.5)	23.7 (22.8, 25.2)	1
61 – 70 years	25.6	26.5 (24.4, 28.8)	45.4 (42.9, 47.9)	17.7 (15.9, 19.6)	10.4 (9.0, 11.9)	28.1 (25.6, 30.3)	1.23*** (1.10–1.42)
71+ years	18.2	20.8 (18.6, 23.3)	52.2 (49.4, 55.1)	18.8 (16.7, 21.0)	8.2 (6.8, 9.8)	26.9 (24.6, 29.5)	1.85 (0.99–1.42)
Marital status							
Not currently married	28.2	24.7 (22.7, 26.8)	46.9 (44.6, 49.2)	19.3 (17.5, 21.2)	9.1 (8.0, 10.5)	28.4 (26.4, 30.5)	1
Currently married	71.8	32.7 (31.3, 34.1)	43.1 (41.6, 44.6)	15.4 (14.4, 16.5)	8.8 (8.0, 9.7)	24.2 (23.0, 25.5)	1.05 (0.89–1.21)
Educational level							
No education	53.3	31.3 (29.7, 33.0)	47.7 (45.9, 49.4)	14.1 (13.0, 15.4)	6.9 (6.1, 7.8)	21.0 (19.7, 22.4)	1
Primary	23.8	30.0 (27.6, 32.4)	42.8 (40.2, 45.4)	18.2 (16.3, 20.3)	9.0 (7.7, 10.6)	27.2 (25.0, 29.6)	1.35*** (1.16–1.57)
Junior high school	7.8	30.9 (27.0, 35.1)	34.8 (30.7, 39.1)	20.2 (16.9, 23.9)	14.2 (11.4, 17.5)	34.4 (30.3, 38.6)	1.66*** (1.33–2.06)
Senior high school	10.0	30.4 (26.9, 34.1)	38.7 (35.0, 42.6)	18.0 (15.3, 21.1)	12.8 (10.4, 15.7)	30.9 (27.4, 34.5)	1.23 (0.99–1.53)
Tertiary	5.1	22.8 (18.5, 27.8)	38.7 (33.5, 44.2)	24.4 (20.0, 29.4)	14.1 (10.6, 18.4)	38.4 (33.3, 43.9)	1.77*** (1.33–2.36)
Ethnicity							
Javanese	56.3	31.3 (29.7, 33.0)	45.7 (44.0, 47.5)	15.2 (14.0, 16.5)	7.7 (6.8, 8.6)	22.9 (21.5, 24.4)	1
Sundanese	15.5	22.9 (20.1 25.9)	43.4 (40.0, 46.8)	21.1 (18.4, 24.0)	12. (10.6, 15.1)	33.7 (30.6, 37.0)	1.53*** (1.28–1.83)
Others	28.2	32.7 (30.8, 34.7)	41.5 (39.4, 43.5)	16.5 (15.1, 18.0)	9.3 (8.2, 10.6)	25.8 (24.1, 27.6)	1.04 (0.89–1.22)
Had any health insurance							
No	53.9	32.4 (30.8, 34.1)	46.2 (44.4, 47.9)	14.3 (13.1, 15.5)	7.1 (6.3, 8.1)	21.4 (20.1, 22.9)	1
Yes	46.1	28.1 (26.5, 29.8)	41.8 (40.0, 43.6)	19.0 (17.7, 20.5)	11.0 (9.9, 12.2)	30.0 (28.4, 31.7)	1.22*** (1.23–1.57)
Type of work							
Unemployed	30.6	19.8 (18.1, 21.7)	44.2 (42.0, 46.4)	21.3 (19.6, 23.2)	14.6 (13.2, 16.3)	36.0 (33.9, 38.1)	1
Casual	15.6	36.1 (33.0, 39.4)	45.5 (42.2, 48.7)	13.3 (11.3, 15.7)	5.0 (3.8, 6.6)	18.4 (16.0, 21.0)	0.50*** (0.41–0.62)
Self-employed	39.8	34.6 (32.7, 36.6)	44.4 (42.4, 46.4)	14.5 (13.2, 16.0)	6.4 (5.5, 7.5)	21.0 (19.4, 22.7)	0.57*** (0.49–0.66)
Government/private	14.0	35.2 (32.0, 38.6)	41.9 (38.6, 45.4)	15.0 (12.8, 17.5)	7.8 (6.2, 9.9)	22.8 (20.1, 25.8)	0.50*** (0.40–0.62)
Household expenditure							
Q1 (the lowest)	21.3	33.2 (30.7, 35.9)	49.3 (46.5, 52.1)	12.7 (11.0, 14.6)	4.8 (3.7, 6.1)	17.5 (15.5, 19.6)	1
Q2	20.9	33.5 (30.8, 36.2)	45.0 (42.3, 47.9)	15.6 (13.7, 17.7)	5.8 (4.6, 7.3)	21.5 (19.2, 23.8)	1.28** (1.05–1.58)
Q3	19.8	31.7 (29.1, 34.4)	43.7 (41.0, 46.5)	6.0 (14.0, 18.1)	8.6 (7.2, 10.3)	24.6 (22.2, 17.1)	1.46*** (1.19–1.78)
Q4	19.5	28.8 (26.3, 31.5)	41.5 (38.7, 44.3)	18.8 (16.7, 21.1)	10.9 (9.3, 12.7)	19.7 (27.2, 32.3)	1.80*** (1.47–2.20)
Q5 (the highest)	18.5	24.0 (21.7, 26.5)	40.5 (37.8, 43.3)	19.9 (17.8, 22.2)	15.5 (13.5, 17.6)	35.4 (32.8, 38.1)	2.03*** (1.65–2.50)
Residency							
Rural	48.9	33.3 (31.5, 35.1)	46.4(44.5, 48.3)	14.2 (12.9, 15.5)	6.1 (52.5, 7.0)	20.3 (18.8, 21.8)	1
Urban	51.3	27.7 (26.2, 29.2)	42.0 (40.3, 43.7)	19.0 (17.4, 20.0)	11.6 (10.6, 12.7)	30.3 (28.8, 31.9)	1.37*** (1.19–1.56)
Island							
Java-Bali	78.6	30.3 (28.9, 31.7)	44.7 (43.2, 16.2)	16.0 (15.0, 17.1)	9.0 (8.2, 9.9)	25.1 (23.8, 26.4)	1
Sumatra	14.0	30.6 (28.2, 33.1)	41.1 (38.5, 43.7)	19.1 (17.1, 21.2)	9.2 (7.8, 10.8)	28.3 (26.0, 30.7)	1.34*** (1.14–1.58)
Nusa Tenggara	2.4	37.2 (32.9, 41.7)	47.2 (42.7, 51.7)	13.3 (10.5, 16.6)	2.3 (12.8, 4.1)	15.6 (12.6, 19.1)	0.62*** (0.46–0.83)
Kalimantan	2.4	24.3 (19.7, 29.5)	41.5 (36.1, 47.2)	22.9 (18.6, 27.9)	11.3 (8.2, 15.3)	34.2 (29.1, 39.7)	2.02*** (1.53–2.67)
Sulawesi	2.6	33.6 (28.7, 38.9)	44.7 (39.4, 50.0)	14.2 (10.9, 18.4)	7.5 (5.2, 10.6)	21.7 (17.7, 26.4)	0.87 (0.64–1.18)
Overall Sample	100	30.4 (29.3, 31.6)	44.1 (42.9, 45.4)	16.5 (15.6, 17.4)	8.9 (8.2, 9.6)	25.4 (24.3, 26.5)	

[a] Weighted sample size

[b] We defined multimorbidity if the respondents reported that they had 2 or more chronic conditions related to NCDs. Chronic diseases in IFLS5 included hypertension, diabetes mellitus, asthma, chronic heart diseases, mental health issue, stroke, liver diseases, cancer/malignancies, liver, arthritis, high cholesterol, prostate illness kidney diseases, digestive system diseases.

aOR: adjusted odds ratio

*** p<0.01, ** p<0.05

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Table S5. Robustness check: The effect of multimorbidity on health service use (cross-sectional analysis of 2014 IFLS)

Variables	Health service use			
	Outpatient		Inpatient	
	Any visit	Number of visits	Any visit	Number of visits
	aOR (95% CI)	IRR (95% CI)	aOR (95% CI)	IRR (95% CI)
Number of NCDs (ref. no NCD)				
Single NCD	1.54*** (1.30–1.82)	1.50*** (1.24–1.81)	1.73** (1.17–2.56)	2.03*** (1.36–3.03)
Two NCDs	2.77*** (2.29–3.36)	2.68*** (2.15–3.34)	3.47*** (2.31–5.21)	4.03*** (2.66–6.08)
Three or more NCDs	4.51*** (3.61–5.63)	3.85*** (3.06–4.84)	6.85***(4.45–10.52)	8.78*** (5.73–13.45)
Sex (ref. Male)				
Female	1.26***(1.09–1.45)	1.18**(1.02–1.35)	0.93 (0.72–1.22)	0.81 (0.62–1.07)
Age (ref. 50 – 60 years)				
61 – 70 years	1.01 (0.87–1.18)	0.93 (0.80–1.08)	1.23 (0.91–1.65)	1.23 (0.88–1.72)
71+ years	1.03 (0.85–1.25)	1.01 (0.84–1.21)	1.42 (1.02–2.00)	1.53** (1.01–2.32)
Marital status (ref. Not married)				
Currently married	1.09 (0.93–1.27)	1.04 (0.90–1.21)	1.07 (0.80–1.41)	0.93 (0.70–1.25)
Educational level (ref. No education)				
Primary	0.94 (0.80–1.10)	0.87* (0.74–1.01)	1.02 (0.75–1.39)	0.96 (0.69–1.35)
Junior high school	1.02 (0.80–1.31)	1.07 (0.76–1.52)	0.72 (0.45–1.14)	0.82 (0.47–1.44)
Senior high school	0.87 (0.68–1.10)	0.80* (0.64–1.00)	0.69 (0.44–1.08)	0.63* (0.39–1.00)
Tertiary	0.99 (0.73–1.33)	0.79 (0.55–1.13)	0.58* (0.33–1.02)	0.55* (0.30–1.00)
Ethnicity (ref. Javanese)				
Sundanese	0.93 (0.77–1.13)	0.97 (0.81–1.17)	1.17 (0.84–1.63)	1.21 (0.82–1.79)
Others	1.06 (0.89–1.25)	0.99 (0.84–1.17)	0.78 (0.56–1.08)	0.87 (0.62–1.22)
Insurance coverage (ref. No)				
Yes	1.20*** (1.06–1.37)	1.25*** (1.10–1.44)	2.28*** (1.77–2.95)	2.19*** (1.66–2.89)
Type of work (ref. Unemployed)				
Casual	0.73*** (0.59–0.90)	0.73*** (0.60–0.89)	0.41*** (0.25–0.67)	0.35*** (0.22–0.55)
Self-employed	0.77*** (0.66–0.90)	0.77*** (0.66–0.90)	0.64*** (0.47–0.87)	0.64*** (0.46–0.90)
Government/private	0.70*** (0.56–0.88)	0.75*** (0.60–0.93)	0.43*** (0.28–0.66)	0.53** (0.30–0.94)
Per capita expenditure (ref. Q1)				
Q2	1.36*** (1.10–1.68)	1.40*** (1.14–1.73)	0.86 (0.57–1.31)	0.76 (0.48–1.18)
Q3	1.50*** (1.21–1.85)	1.71*** (1.35–2.17)	1.16 (0.78–1.72)	1.29 (0.80–2.05)
Q4	1.93*** (1.56–2.38)	1.75*** (1.44–2.14)	1.24 (0.83–1.85)	1.35 (0.87–2.08)
Q5	1.87*** (1.50–2.33)	2.02*** (1.63–2.51)	2.06*** (1.38–3.06)	1.98*** (1.32–2.96)
Residency (ref. Rural)				
Urban	0.94 (0.82–1.08)	0.98 (0.86–1.13)	0.93 (0.71–1.21)	1.03 (0.79–1.34)
Region (ref. Java-Bali)				
Sumatra	0.72*** (0.60–0.86)	0.86 (0.72–1.03)	1.32 (0.96–1.82)	1.46** (1.04–2.06)
Nusa Tenggara	0.84 (0.63–1.12)	0.84 (0.63–1.12)	1.83** (1.09–3.06)	1.87** (1.08–3.25)
Kalimantan	0.81 (0.59–1.11)	0.85 (0.62–1.14)	1.46 (0.82–2.58)	1.4 (0.81–2.42)
Sulawesi	0.54*** (0.39–0.75)	0.53*** (0.39–0.71)	1.45 (0.81-2.60)	1.59 (0.85–2.98)

Chronic diseases in IFLS5 included hypertension-diabetes mellitus-asthma-chronic heart diseases-mental health issue-stroke-liver diseases-cancer/malignancies-liver-arthritis-high cholesterol-prostate illness kidney diseases-digestive system diseases.
aOR: adjusted odds ratio, IRR: incidence rate ratio, NCD: noncommunicable disease
*** p<0.01, ** p<0.05

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Table S6. Robustness check: The effect of multimorbidity on catastrophic health expenditure (cross-sectional analysis of 2014 IFLS)

Variables	Catastrophic health expenditure		
	10% of total household expenditure	25% of total household expenditure	40% of non-food expenditure
	aOR (95% CI)	aOR (95% CI)	aOR (95% CI)
Number of NCDs (ref. no NCD)			
Single NCD	1.25 (0.94–1.66)	1.18 (0.67–2.09)	1.58 (0.98–2.57)
Two NCDs	2.03*** (1.48–2.79)	2.10** (1.12–3.93)	2.39*** (1.38–4.14)
Three or more NCDs	2.24*** (1.57–3.20)	2.09** (1.06–4.12)	2.17** (1.18–4.01)
Sex (ref. Male)			
Female	0.87 (0.68–1.12)	0.74 (0.43–1.27)	0.90 (0.59–1.37)
Age (ref. 50 – 60 years)			
61 – 70 years	1.24 (0.96–1.60)	1.34 (0.82–2.20)	1.42 (0.94–2.14)
71+ years	1.32 (0.96–1.81)	1.06 (0.53–2.13)	1.48 (0.88–2.51)
Marital status (ref. Not married)			
Currently married	1.44** (1.08–1.91)	1.69* (0.91–3.17)	1.94*** (1.20–3.14)
Educational level (ref. No education)			
Primary	1.14 (0.88–1.48)	1.31 (0.79–2.17)	1.46 (0.98–2.18)
Junior high school	1.11 (0.76–1.63)	1.28 (0.67–2.46)	1.12 (0.63–1.98)
Senior high school	0.73 (0.49–1.08)	0.52 (0.22–1.23)	0.45** (0.21–0.97)
Tertiary	0.74 (0.43–1.27)	0.22 (0.05–1.01)	0.12** (0.02–0.66)
Ethnicity (ref. Javanese)			
Sundanese	0.87 (0.64–1.18)	1.09 (0.62–1.89)	0.83 (0.51–1.35)
Others	0.79 (0.60–1.04)	0.65 (0.36–1.18)	0.47*** (0.28–0.78)
Insurance coverage (ref. No)			
Yes	1 (0.81–1.25)	1.07 (0.71–1.61)	1.02 (0.72–1.44)
Type of work (ref. Unemployed)			
Casual	0.66** (0.46–0.95)	0.56 (0.27–1.16)	0.56 (0.31–1.04)
Self-employed	0.70*** (0.53–0.91)	0.44*** (0.24–0.79)	0.54*** (0.34–0.85)
Government/private	0.57*** (0.39–0.83)	0.41** (0.19–0.88)	0.46** (0.23–0.91)
Per capita expenditure (ref. Q1)			
Q2	0.96 (0.65–1.43)	1.05 (0.47–2.35)	1.24 (0.67–2.33)
Q3	1.42 (0.99–2.02)	1 (0.46–2.17)	1.08 (0.58–2.01)
Q4	1.59** (1.11–2.27)	2.37** (1.15–4.86)	2.18*** (1.21–3.92)
Q5	2.53*** (1.76–3.62)	2.44** (1.18–5.05)	2.75*** (1.51–5.02)
Residency (ref. Rural)			
Urban	1.01 (0.80–1.26)	0.87 (0.56–1.37)	0.94 (0.65–1.35)
Region (ref. Java-Bali)			
Sumatra	0.94 (0.71–1.24)	0.94 (0.55–1.60)	1.36 (0.88–2.09)
Nusa Tenggara	0.81 (0.48–1.37)	1.49 (0.59–3.76)	1.57 (0.68–3.66)
Kalimantan	1.13 (0.69–1.84)	1.5 (0.59–3.83)	1.56 (0.71–3.47)
Sulawesi	1.02 (0.60–1.73)	0.4 (0.08–2.07)	1.18 (0.45–3.10)

Chronic diseases in IFLS5 included hypertension-diabetes mellitus-asthma-chronic heart diseases-mental health issue-stroke-liver diseases-cancer/malignancies-liver-arthritis-high cholesterol-prostate illness kidney diseases-digestive system diseases.
aOR: adjusted odds ratio, IRR: incidence rate ratio, NCD: noncommunicable disease
*** p<0.01, ** p<0.05

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Table S7. Robustness check: The effect of multimorbidity on productivity loss (cross-sectional analysis of 2014 IFLS)

Variables	Productivity loss		
	Labour participation	Days primary activity missed	Days stayed in bed
	aOR (95% CI)	IRR (95% CI)	IRR (95% CI)
Number of NCDs (ref. no NCD)			
Single NCD	0.76*** (0.65–0.89)	1.48*** (1.29–1.70)	1.32** (1.01–1.72)
Two NCDs	0.54*** (0.45–0.65)	2.42*** (2.09–2.80)	2.18*** (1.60–2.97)
Three or more NCDs	0.32*** (0.26–0.40)	3.29*** (2.79–3.87)	2.80*** (2.02–3.88)
Sex (ref. Male)			
Female	0.31***(0.27–0.35)	1.05 (0.94–1.18)	1.22 (0.97–1.54)
Age (ref. 50 – 60 years)			
61 – 70 years	0.40*** (0.34–0.46)	0.97 (0.86–1.10)	0.93 (0.72–1.21)
71+ years	0.15*** (0.13–0.18)	1.19** (1.03–1.37)	1.78*** (1.33–2.36)
Marital status (ref. Not married)			
Currently married	1.22*** (1.05–1.41)	1.07 (0.95–1.20)	0.93 (0.72–1.21)
Primary	1.08 (0.92–1.26)	1.02 (0.90–1.17)	1.03 (0.81–1.32)
Junior high school	0.64*** (0.51–0.81)	1.02 (0.85–1.22)	1.01 (0.64–1.61)
Senior high school	0.61*** (0.49–0.76)	0.73*** (0.60–0.89)	0.73 (0.46–1.15)
Tertiary	1.09 (0.79–1.48)	0.59*** (0.43–0.83)	0.37*** (0.19–0.71)
Ethnicity (ref. Javanese)			
Sundanese	0.69*** (0.57–0.83)	1.25*** (1.10–1.43)	1.70*** (1.29–2.24)
Others	0.72*** (0.61–0.86)	0.93 (0.81–1.07)	1.34** (1.01–1.77)
Insurance coverage (ref. No)			
Yes	0.91 (0.80–1.04)	1.02 (0.92–1.13)	0.87 (0.71–1.06)
Type of work (ref. Unemployed)			
Casual	n/a	0.51*** (0.43–0.60)	0.28*** (0.20–0.39)
Self-employed		0.55*** (0.49–0.63)	0.33*** (0.26–0.42)
Government/private		0.44*** (0.37–0.54)	0.22*** (0.14–0.33)
Per capita expenditure (ref. Q1)			
Q2	1.25** (1.03–1.52)	1.02 (0.88–1.19)	1.11 (0.82–1.51)
Q3	1.17 (0.96–1.43)	1.12 (0.95–1.32)	0.8 (0.59–1.09)
Q4	0.96 (0.79–1.17)	0.95 (0.81–1.12)	0.89 (0.66–1.21)
Q5	1.07 (0.86–1.32)	1.02 (0.86–1.20)	0.83 (0.61–1.14)
Residency (ref. Rural)			
Urban	0.57*** (0.50–0.65)	1 (0.90–1.12)	0.88 (0.72–1.09)
Region (ref. Java-Bali)			
Sumatra	1.04 (0.87–1.23)	1.12 (0.97–1.29)	1.03 (0.78–1.36)
Nusa Tenggara	1.17 (0.89–1.54)	1.14 (0.92–1.42)	0.91 (0.59–1.40)
Kalimantan	1.42** (1.02–1.99)	1.16 (0.91–1.48)	0.73 (0.48–1.10)
Sulawesi	0.59*** (0.43–0.79)	1.39** (1.07–1.81)	1.05 (0.70–1.59)

Chronic diseases in IFLS5 included hypertension-diabetes mellitus-asthma-chronic heart diseases-mental health issue-stroke-liver diseases-cancer/malignancies-liver-arthritis-high cholesterol-prostate illness kidney diseases-digestive system diseases.
aOR: adjusted odds ratio, IRR: incidence rate ratio, NCD: noncommunicable disease
*** p<0.01, ** p<0.05

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Table S8. Sensitivity analysis: the effect of multimorbidity on health service use

Obesity (BMI ≥25 kg/m2 as obese) is included in the clustering of multimorbidity

Variables	Health service use							
	Outpatient				Inpatient			
	Any visit[a)]		Number of visits[b)]		Any visit[a)]		Number of visits[b)]	
	aOR (95% CI)	p values	IRR (95% CI)	p values	aOR (95% CI)	p values	IRR (95% CI)	p values
Number of NCDs (ref. no NCD)								
Single NCD	1.18 (0.98–1.43)	0.086	1.24 (1.04–1.50)	0.020	1.16 (0.79–1.70)	0.451	1.16 (0.79–1.70)	0.488
Two NCDs	1.82 (1.47–2.25)	0.000	1.83 (1.50–2.25)	0.000	1.78 (1.18–2.69)	0.006	1.78 (1.18–2.69)	0.002
Three or more NCDs	3.27 (2.55–4.19)	0.000	2.85 (2.26–3.60)	0.000	2.73 (1.76–4.25)	0.000	2.73 (1.76–4.25)	0.000
Period (ref.2007)								
2014	1.33 (1.15–1.53)	0.000	1.29 (1.12–1.49)	0.000	1.72 (1.29–2.29)	0.000	1.72 (1.29–2.29)	0.000
Sex (ref. Male)								
Female	1.19 (1.00–1.41)	0.049	1.13 (0.96–1.33)	0.139	0.91 (0.67–1.24)	0.537	0.91 (0.67–1.24)	0.413
Age (ref. 50 – 60 years)								
61 – 70 years	1.06 (0.90–1.26)	0.475	1.05 (0.89–1.23)	0.588	1.09 (0.79–1.50)	0.603	1.09 (0.79–1.50)	0.332
71+ years	1.20 (0.96–1.50)	0.109	1.15 (0.93–1.41)	0.187	1.58 (1.07–2.33)	0.020	1.58 (1.07–2.33)	0.020
Marital status (ref. Not married)								
Currently married	1.09 (0.92–1.31)	0.323	1.15 (0.97–1.36)	0.105	1.05 (0.77–1.44)	0.742	1.05 (0.77–1.44)	0.962
Educational level (ref. No education)								
Primary	1.06 (0.88–1.27)	0.556	0.97 (0.82–1.16)	0.760	1.09 (0.78–1.51)	0.630	1.09 (0.78–1.51)	0.796
Junior high school	1.04 (0.78–1.40)	0.777	1.11 (0.85–1.46)	0.441	1.18 (0.73–1.92)	0.498	1.18 (0.73–1.92)	0.105
Senior high school	1.01 (0.76–1.35)	0.954	0.94 (0.72–1.23)	0.636	0.78 (0.47–1.29)	0.335	0.78 (0.47–1.29)	0.147
Tertiary	1.18 (0.79–1.76)	0.427	0.84 (0.57–1.23)	0.371	0.94 (0.50–1.78)	0.858	0.94 (0.50–1.78)	0.495
Ethnicity (ref. Javanese)								
Sundanese	0.91 (0.72–1.16)	0.456	0.92 (0.74–1.15)	0.486	0.90 (0.59–1.37)	0.628	0.90 (0.59–1.37)	0.944
Others	1.02 (0.85–1.24)	0.802	0.92 (0.77–1.09)	0.313	0.91 (0.65–1.28)	0.603	0.91 (0.65–1.28)	0.557
Insurance coverage (ref. No)								
Yes	1.48 (1.27–1.73)	0.000	1.57 (1.36–1.81)	0.000	2.02 (1.52–2.69)	0.000	2.02 (1.52–2.69)	0.000
Type of work (ref. Unemployed)								
Casual	0.77 (0.61–0.97)	0.025	0.66 (0.53–0.82)	0.000	0.48 (0.30–0.79)	0.003	0.48 (0.30–0.79)	0.001
Self-employed	0.83 (0.70–0.99)	0.041	0.76 (0.64–0.89)	0.001	0.60 (0.43–0.83)	0.002	0.60 (0.43–0.83)	0.001
Government/private	0.74 (0.56–0.98)	0.034	0.67 (0.52–0.88)	0.004	0.61 (0.36–1.02)	0.061	0.61 (0.36–1.02)	0.242
Per capita household expenditure (ref. Q1)								
Q2	1.48 (1.17–1.86)	0.001	1.50 (1.20–1.87)	0.000	1.26 (0.80–2.01)	0.322	1.26 (0.80–2.01)	0.500
Q3	1.71 (1.35–2.15)	0.000	1.74 (1.39–2.17)	0.000	1.77 (1.14–2.76)	0.012	1.77 (1.14–2.76)	0.003
Q4	1.70 (1.34–2.16)	0.000	1.77 (1.41–2.22)	0.000	1.44 (0.90–2.31)	0.131	1.44 (0.90–2.31)	0.092
Q5	1.79 (1.39–2.31)	0.000	1.98 (1.56–2.51)	0.000	2.67 (1.68–4.26)	0.000	2.67 (1.68–4.26)	0.000
Residency (ref. Rural)								
Urban	0.87 (0.74–1.02)	0.093	0.92 (0.79–1.07)	0.258	0.96 (0.72–1.28)	0.775	0.96 (0.72–1.28)	0.689
Region (ref. Java-Bali)								
Sumatra	0.83 (0.67–1.03)	0.094	1.03 (0.85–1.26)	0.736	1.21 (0.84–1.75)	0.294	1.21 (0.84–1.75)	0.322
Nusa Tenggara	0.69 (0.48–0.99)	0.043	0.62 (0.44–0.87)	0.006	1.24 (0.69–2.22)	0.467	1.24 (0.69–2.22)	0.707
Kalimantan	1.04 (0.71–1.50)	0.851	1.31 (0.94–1.83)	0.115	0.99 (0.50–1.97)	0.982	0.99 (0.50–1.97)	0.764
Sulawesi	0.72 (0.48–1.07)	0.107	0.68 (0.47–0.99)	0.043	0.52 (0.22–1.22)	0.134	0.52 (0.22–1.22)	0.055

[a)] Multilevel logistic regression model

[b)] Multilevel negative binomial regression model

Obesity (BMI ≥25 kg/m2 as obese) is included in the clustering of multimorbidity

aOR: adjusted odds ratio, IRR: Incidence rate ratio, NCD: noncommunicable disease

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Table S9. Sensitivity analysis: the effect of multimorbidity on catastrophic expenditure

Obesity (BMI ≥25 kg/m2 as obese) is included in the clustering of multimorbidity

Variables	Catastrophic health expenditure					
	10% of total household expenditure[a)]		25% of total household expenditure[a)]		40% of non-food expenditur [a)]	
	aOR (95% CI)	p values	aOR (95% CI)	p values	aOR (95% CI)	p values
Number of NCDs (ref. no NCD)						
Single NCD	1.12 (0.84–1.51)	0.434	0.89 (0.54–1.47)	0.642	0.93 (0.62–1.41)	0.743
Two NCDs	1.23 (0.88–1.72)	0.235	1.27 (0.74–2.17)	0.382	1.22 (0.77–1.91)	0.396
Three or more NCDs	1.66 (1.12–2.45)	0.011	0.99 (0.50–1.94)	0.976	1.08 (0.63–1.88)	0.773
Period (ref.2007)						
2014	1.37 (1.09–1.74)	0.008	1.21 (0.81–1.81)	0.351	1.16 (0.84–1.62)	0.367
Sex (ref. Male)						
Female	0.92 (0.72–1.19)	0.528	1.00 (0.64–1.54)	0.991	1.01 (0.70–1.45)	0.949
Age (ref. 50 – 60 years)						
61 – 70 years	1.18 (0.91–1.53)	0.207	1.47 (0.95–2.29)	0.085	1.49 (1.03–2.16)	0.033
71+ years	1.08 (0.77–1.53)	0.651	0.87 (0.45–1.67)	0.672	1.37 (0.83–2.25)	0.218
Marital status (ref. Not married)						
Currently married	1.54 (1.15–2.05)	0.003	1.66 (1.01–2.71)	0.044	1.82 (1.21–2.72)	0.004
Educational level (ref. No education)						
Primary	0.93 (0.70–1.23)	0.607	0.87 (0.53–1.44)	0.596	0.88 (0.59–1.31)	0.530
Junior high school	0.88 (0.57–1.35)	0.555	1.04 (0.51–2.09)	0.921	0.67 (0.35–1.28)	0.227
Senior high school	0.85 (0.55–1.29)	0.442	1.05 (0.53–2.07)	0.885	0.82 (0.45–1.47)	0.500
Tertiary	0.39 (0.18–0.84)	0.016	0.13 (0.02–0.96)	0.045	0.18 (0.04–0.75)	0.018
Ethnicity (ref. Javanese)						
Sundanese	0.83 (0.57–1.21)	0.339	1.64 (0.91–2.95)	0.099	1.17 (0.71–1.94)	0.529
Others	0.75 (0.56–1.02)	0.069	0.96 (0.57–1.60)	0.872	0.72 (0.47–1.10)	0.129
Insurance coverage (ref. No)						
Yes	0.94 (0.74–1.20)	0.613	0.83 (0.54–1.27)	0.388	0.80 (0.56–1.15)	0.227
Type of work (ref. Unemployed)						
Casual	0.62 (0.42–0.91)	0.016	0.59 (0.31–1.14)	0.116	0.56 (0.33–0.95)	0.032
Self-employed	0.64 (0.47–0.87)	0.005	0.65 (0.41–1.03)	0.068	0.66 (0.45–0.97)	0.033
Government/private	0.61 (0.38–0.97)	0.038	0.77 (0.37–1.61)	0.488	0.63 (0.33–1.22)	0.169
Per capita household expenditure (ref. Q1)						
Q2	1.11 (0.74–1.65)	0.619	1.40 (0.66–2.94)	0.379	1.54 (0.85–2.77)	0.151
Q3	1.46 (0.99–2.15)	0.058	1.74 (0.85–3.58)	0.130	1.67 (0.93–2.99)	0.086
Q4	2.01 (1.34–3.01)	0.001	2.58 (1.27–5.26)	0.009	2.42 (1.36–4.31)	0.003
Q5	3.27 (2.10–5.11)	0.000	4.64 (2.29–9.38)	0.000	4.71 (2.66–8.34)	0.000
Residency (ref. Rural)						
Urban	0.99 (0.74–1.31)	0.936	0.85 (0.52–1.40)	0.526	0.88 (0.59–1.32)	0.550
Region (ref. Java-Bali)						
Sumatra	0.82 (0.58–1.16)	0.257	0.78 (0.43–1.41)	0.411	1.12 (0.70–1.78)	0.633
Nusa Tenggara	0.70 (0.37–1.35)	0.287	1.22 (0.39–3.77)	0.730	0.87 (0.33–2.29)	0.772
Kalimantan	0.86 (0.46–1.59)	0.632	0.77 (0.26–2.30)	0.637	0.96 (0.40–2.26)	0.918
Sulawesi	0.83 (0.43–1.61)	0.584	1.00 (0.36–2.79)	0.994	1.08 (0.44–2.63)	0.864

[a)] Multilevel logistic regression model

Obesity (BMI ≥25 kg/m2 as obese) is included in the clustering of multimorbidity

aOR: adjusted odds ratio, NCD: noncommunicable disease

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Table S10. Sensitivity analysis: the effect of multimorbidity on productivity loss

Obesity (BMI ≥25 kg/m2 as obese) is included in the clustering of multimorbidity

Variables	Productivity loss					
	Labour participation[a)]		Days primary activity missed[b)]		Days stayed in bed[b)]	
	aOR (95% CI)	p values	IRR (95% CI)	p values	IRR (95% CI)	p values
Number of NCDs (ref. no NCD)						
Single NCD	0.66 (0.54–0.82)	0.000	1.16 (0.99–1.36)	0.063	1.10 (0.82–1.48)	0.533
Two NCDs	0.45 (0.35–0.58)	0.000	1.70 (1.41–2.04)	0.000	1.37 (0.98–1.92)	0.065
Three or more NCDs	0.37 (0.27–0.49)	0.000	2.21 (1.76–2.76)	0.000	2.16 (1.44–3.25)	0.000
Period (ref. 2007)						
2014	0.76 (0.65–0.89)	0.001	1.54 (1.35–1.75)	0.000	1.44 (1.13–1.85)	0.004
Sex (ref. Male)						
Female	0.22 (0.17–0.27)	0.000	0.96 (0.83–1.11)	0.555	0.90 (0.68–1.20)	0.480
Age (ref. 50 – 60 years)						
61 – 70 years	0.36 (0.29–0.44)	0.000	1.02 (0.89–1.18)	0.758	1.15 (0.87–1.52)	0.336
71+ years	0.10 (0.08–0.13)	0.000	1.17 (0.97–1.41)	0.094	1.77 (1.24–2.52)	0.002
Marital status (ref. Not married)						
Currently married	1.49 (1.22–1.82)	<0.0001	1.18 (1.01–1.37)	0.032	0.96 (0.72–1.29)	0.809
Educational level (ref. No education)						
Primary	0.90 (0.72–1.13)	0.372	0.92 (0.79–1.07)	0.269	1.03 (0.77–1.38)	0.851
Junior high school	0.41 (0.29–0.58)	<0.0001	0.91 (0.71–1.16)	0.438	0.68 (0.42–1.10)	0.118
Senior high school	0.43 (0.30–0.61)	<0.0001	0.64 (0.50–0.83)	0.001	0.65 (0.40–1.04)	0.073
Tertiary	0.56 (0.34–0.92)	0.021	0.52 (0.36–0.75)	<0.0001	0.42 (0.20–0.88)	0.022
Ethnicity (ref. Javanese)						
Sundanese	0.48 (0.36–0.65)	<0.0001	1.39 (1.14–1.70)	0.001	1.51 (1.03–2.21)	0.035
Others	0.80 (0.63–1.01)	0.059	1.13 (0.97–1.33)	0.123	1.13 (0.84–1.53)	0.425
Insurance coverage (ref. No)						
Yes	0.82 (0.69–0.98)	0.032	1.13 (0.99–1.29)	0.077	1.13 (0.88–1.46)	0.329
Type of work (ref. Unemployed)						
Casual	N/A	N/A	0.69 (0.57–0.84)	<0.0001	0.41 (0.28–0.60)	<0.0001
Self-employed	N/A	N/A	0.68 (0.58–0.79)	<0.0001	0.51 (0.38–0.69)	<0.0001
Government/private	N/A	N/A	0.60 (0.47–0.76)	<0.0001	0.56 (0.35–0.90)	0.017
Per capita household expenditure (ref. Q1)						
Q2	1.36 (1.06–1.75)	0.016	1.03 (0.85–1.24)	0.769	0.97 (0.68–1.38)	0.848
Q3	1.27 (0.98–1.64)	0.071	1.17 (0.97–1.42)	0.095	1.11 (0.78–1.59)	0.557
Q4	1.13 (0.86–1.47)	0.383	1.05 (0.86–1.29)	0.602	0.99 (0.68–1.43)	0.944
Q5	1.35 (1.01–1.80)	0.043	1.26 (1.02–1.55)	0.032	0.89 (0.60–1.33)	0.577
Residency (ref. Rural)						
Urban	0.42 (0.34–0.52)	<0.0001	0.92 (0.80–1.06)	0.239	0.69 (0.52–0.90)	0.006
Region (ref. Java-Bali)						
Sumatra	0.91 (0.70–1.20)	0.519	1.14 (0.95–1.38)	0.162	1.10 (0.78–1.55)	0.573
Nusa Tenggara	0.68 (0.44–1.04)	0.077	0.86 (0.64–1.15)	0.309	1.15 (0.66–2.00)	0.629
Kalimantan	1.22 (0.75–1.99)	0.418	0.86 (0.63–1.17)	0.329	0.92 (0.51–1.67)	0.794
Sulawesi	0.34 (0.21–0.55)	<0.0001	1.05 (0.76–1.46)	0.754	1.07 (0.58–1.98)	0.826

[a)] Multilevel logistic regression model

[b)] Multilevel negative binomial regression model

aOR: adjusted odds ratio, IRR: incidence rate ratio, NCD: noncommunicable disease

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STROBE Statement

	Item	Recommendation	Reported on page	Relevant text from manuscript
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1	"Panel Data Analysis"
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2	"Multimorbidity is associated with substantial direct and indirect costs to individuals, households, and the wider society."
Introduction				
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	6	"Evidence from high-income countries (HICs) has found that…"
Objectives	3	State specific objectives, including any prespecified hypotheses	6	"to examine NCD multimorbidity levels, and their relation to households' socioeconomic characteristics, health service use, catastrophic health expenditures, and productivity loss."
Methods				
Study design	4	Present key elements of study design early in the paper	7	"We utilised panel data from two waves of the Indonesian Family Life Survey (IFLS)."
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	7	"Waves 5 was conducted between September 2014–March 2015."
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	7	"This study included respondents aged 50 years and above in 2007 who participated in both Waves 4 and 5, and excluded those with missing values for the study variable."
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	7–8	In "variables" subsection.
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	7–8	In "variables" subsection. Details of the measurements are available in Table S1

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	Item	Recommendation	Reported on page	Relevant text from manuscript
Bias	9	Describe any efforts to address potential sources of bias	11	"Taking into account the hierarchical (nested) nature of the dataset (i.e. observations nested within individuals, and individuals nested within households, and districts), a multilevel level model approach was used."
Study size	10	Explain how the study size was arrived at	7	Our final sample is 3,678 respondents (the sample flowchart is presented in Figure S1).
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	7	In "variables" subsection, i.e. "A total of 10 NCDs were used to quantify the number of NCDs (0, 1, 2, 3 or more) and respondents with two or more NCDs were categorised as having multimorbidity (categorised as 0 or 1)"
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	11	In "statistical analysis" subsection. For example "…, adjusting for covariates"
		(*b*) Describe any methods used to examine subgroups and interactions	11	"We described the patterns of multimorbidity across different population subgroups…"
		(*c*) Explain how missing data were addressed	7	"…excluded those who did not participate in both Waves 4 and 5, and those with missing values for the study"
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy	11	"The results of the descriptive analysis were presented as numbers and weighted percentages with their 95% confidence interval (CI). …"
		(*e*) Describe any sensitivity analyses	11	"We conducted two robustness analyses."
Results				
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	1 (supplementary file)	Figure S1: Sampling flow chart

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	Item	Recommendation	Reported on page	Relevant text from manuscript
		(b) Give reasons for non-participation at each stage	1 (supplementary file)	Figure S1: Sampling flow chart
		(c) Consider use of a flow diagram	1 (supplementary file)	Figure S1: Sampling flow chart
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	1 (supplementary file)	Figure S1: Sampling flow chart
		(b) Indicate number of participants with missing data for each variable of interest	1 (supplementary file)	Figure S1: Sampling flow chart
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)		N/A
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time		N/A
		Case-control study—Report numbers in each exposure category, or summary measures of exposure		N/A
		Cross-sectional study—Report numbers of outcome events or summary measures	25–26	Table 1 and Table 2
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	18–21	Table 2 – Table 5. For example, "Respondents with a single NCD were 1.61 times more likely (95% CI 1.21–2.14) to have experienced an outpatient visit in the past four weeks compared to those without an NCD."
		(*b*) Report category boundaries when continuous variables were categorised	2 (supplementary file)	Table S1: List of variables for 2007 and 2014 IFLS analyses
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period		N/A
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	6–12 (supplementary file)	Tables S6–10. For example, "Our robustness analysis using cross-sectional analysis using 2014 cross-sectional dataset that consists of 14 physical NCDs (Tables S6–10) showed consistent results"
Discussion				

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	Item	Recommendation	Reported on page	Relevant text from manuscript
Key results	18	Summarise key results with reference to study objectives	15	"Multimorbidity was associated with significantly higher use of healthcare services, higher probability of catastrophic health expenditure, and a significant reduction in productivity."
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	18	"There are several limitations to our study."
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	18	"Our findings should be interpreted with caution since the assessment of chronic diseases was mostly based on self-reporting"
Generalisability	21	Discuss the generalisability (external validity) of the study results	19	"This research intentionally focused on the older population due to a significantly higher burden of NCDs in this population group."
Other information				
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	20	Funding This research received no specific grant from any funding agency in the public, commercial or not-for-profit sectors.

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